ENGINEERING NEWS

A JOURNAL OF CIVIL, MECHANICAL, MINING AND ELECTRICAL ENGINEERING

Vol. LIII. No. 16. 220 Broadway, New York, April 20, 1905.

TABLE OF CONTENTS

LEADING ARTICLES:	Page
British Refuse Destructors (illustrated—continued from page 382)	405
The Proportions of Ingredients in Portland Cement Concrete (illustrated); Richard T. Dana, Assoc. M. Am. Soc. C. E.	408
The New British Regulations for the Use of Heavy Motor Vehicles	409
A New Coal-Loading Plant at Lorain, O. (illustrated); W. M. Ray	410
The Burning Out of Electric Street Car Controllers (illustrated); Sydney W. Ashe, B. S.	411
The New Artesian Water Supply of Ithaca, N. Y. (illustrated); F. L. Getman	412
An Air-Compressor with Mechanically Controlled Poppet-Valves (illustrated);	414
Work of the Locomotive Testing Plant at the St. Louis Exhibition	415
A Rail Loading and Unloading Machine (illustrated)	416
A Reinforced Concrete Roof with a Span of Over One Hundred Feet (illustrated)	422
Report of the Chief Engineer of the Panama Canal (with Maps)	422
Municipal Street Railways in Chicago	426
EDITORIAL	417
A Board of Consulting Engineers on the Plan for the Panama Canal Construction.—Chief Engineer Wallace on Plans for a Sea Level Canal.—The Experience of an English Town with Municipal Ownership of its Gas Works.	
Safe Limits of Working Load for Wheel Pressures	417

	Page
LETTERS TO THE EDITOR.—How Far Should Established Rules and Formulas be Subjected to Criticism?—"W."—The Practical Result of Depending upon Individual Citizens to Provide Pure Water for Themselves as Shown at Columbus, O.; R. Winthrop Pratt—The Relation Between Engineers and Architects; Geo. V. Rhines—Discussion of a Court Decision Relating to the Sub-division of Sections of Land (illustrated); F. Hodgman—The Disintegration of Portland Cement by the Action of Oil; Maximilian Toch—The Respective Levels of the Atlantic and Pacific Oceans; Geo. W. Colles—The Pressures on Culverts in High Embankments (illustrated); C. K. Mohler; M. H. Clements, C. E.—Handy Rules for Safe Loads of Steel and Timber Beams; Victor H. Poss—Questions Used in the Examination for Assistant Civil Engineers on Panama Canal Work; "H. L. C."—Additional Manufacturers of Machines for Making Concrete Blocks; Editor "Carpentry and Building"—Notes and Queries.	
NOTES FROM THE ENGINEERING SCHOOLS	426
ENGINEERING NEWS OF THE WEEK	427
PERSONALS	427
ENGINEERING SOCIETIES	428

BRITISH REFUSE DESTRUCTORS.

(Editorial Observations.—Continued from p. 382, April 13, 1905.)

Refuse Destructors Combined with Night-Soil Works, Sewage Works and Sewage Pumping Stations.

Besides the combinations noted immediately above, there are in England several instances of destructors raising steam to pump municipal water supplies.

THE DISPOSAL OF NIGHT-SOIL AND REFUSE AT BIRMINGHAM.

The cleansing department of Birmingham collects and disposes of the ashes, waste paper, garbage, and similar wastes of the city, and is also responsible for the collection and disposal of excreta from such pan closets as have not yet been converted into water closets. The number of pan closets has diminished from 37,000 to 25,000, and is being lessened at the rate of 50 a week. There are five wharves for the reception and treatment of night-soil and for refuse destructor stations, one at least of the latter being combined with poudrette works. At three of the wharves refuse is passed through revolving screens and the fine stuff is mixed with excreta and barged away as crude manure. The poudrette works will soon be abandoned, after which the diminishing quantity of night-soil will all be mixed with ashes, as just described. Some idea of the operations of the cleansing department may be gained from the statement that during 1902 the destructors treated 121,000 long tons of refuse, while 29,000 tons were sent to the tips or dumps, 61,438 tons of mixed night-soil and ashes were barged or carted away, and 731 long tons of this and like matter were tipped. The amount of night-soil made into poudrette is not reported.* Mr. William Holt is superintendent of the cleansing department.

Birmingham has a population of about 520,000 and an area of 12,639 acres. Refuse destructors were first put in use in 1877. In 1879 two large destructors were built. In 1899 a fourth plant (described below) was built, and at the time of my visit, in April, 1904, another plant was under construction and still another was projected. The plants built in 1879 were designed by the department. The projected plant will be built by Heenan & Froude, of Manchester. The other destructors are all of the Fryer type, and were built by Manlove, Alliott & Co., of Nottingham.

The projected plant will be located at the sewage works, and the steam from it will be used to generate electricity for light and power for use at those works. This will be known as the Saltley destructor. There will be eight cells, in two units of four each, top-fed from storage bins by means of hydraulic rams. There will be three boilers. One will be a coal-fired stand-by, for use on holidays and in case of emergency. Heenan & Froude destructors are also under consideration as substitutes for the old Montague St. plant, of local design.

My inspection covered only two of the destructors, which will now be briefly described.

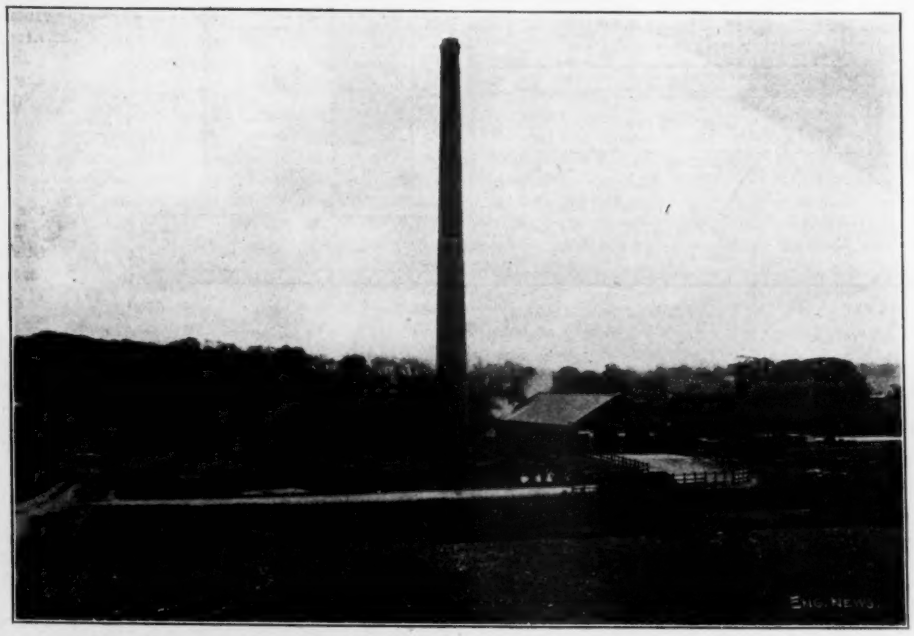


FIG. 1. REFUSE DESTRUCTOR AND SEWAGE PUMPING STATION, WATFORD, ENGLAND.

(Note the solid earth embankment leading up to the destructor.)

THE MONTAGUE ST. DESTRUCTOR.—There are 32 cells here, each with a grate area of about 25 sq. ft. Refuse is stored on the top of the destructors and fed into their tops, but as this does not afford sufficient storage room, some refuse is dumped below and fed into the fronts of the cells. The rough clinker is used for road-making and sewage filter beds, and some is made into slabs for sidewalks by means of a hydraulic press. The tins are now flattened by passing them through corrugated rollers, made into bales of 224 lbs. each, and sold at the works for about 30 shillings, or $7.30, per long ton. The solder is melted out and sold separately. The city supplies the necessary apparatus for handling the tins and gives the workmen who handle them all the solder and about half the amount received for the tins.

There are 14 multitubular boilers at these works, all supplied with heat from the destructors. The steam is used for drying night-soil and for other works purposes. The destructors are operated night and day and burn about 1,000 long tons a week. There was much dirt and dust about this plant, some of which might have been due to the changes in progress.

THE MONTGOMERY ST. DESTRUCTOR.—The twelve Fryer cells here were erected in 1899, are placed back to back and are top-fed by means of Boulnois & Brodie's charging apparatus. The chimney is 195 ft. high above the ground. Forced draft is provided by means of two 6½ or 7-ft. Sturtevant blowers, one to each six cells. Two 8 × 28-ft. Lancashire boilers supply steam to drive the fans and light the works and stables. They could do more work if required.

The refuse is brought into the building over a stone paved ramp and is dumped from a stone paved tipping floor. The clinkering floor is covered with concrete. The building has brick walls and a slate roof. There is a dust deposit chamber about half way between the cells and the chimney. The charging hoppers or trucks hold two wagon loads, or about three long tons each, and there are two trucks to each cell, with a track leading to and beyond the feed hole. The extra truck is for storage. When the trucks are brought over a feed hole the cover of the latter is removed, the bottom of the truck opened and the refuse dropped into the cell.

The stoking and clinkering doors are tight-fitted on a counterbalanced horizontal shaft-hinge. The doors are of double plate iron, with an air space between.

The clinkers are delivered to contractors at one shilling, or 25 cts., per 1½ long tons for hauls of one mile or less, and 6 d., or 12 cts., for each half mile additional. The fine ash from below the grates is sold for various purposes and at the same rates. Some of the flue dust is sold to farmers at the cost of haulage, and some is tipped. Tins, scrap iron, bottles and the like are picked out and sold.

The plant is run 144 hours a week and burns an average of 480 long tons in that time. By doubling the number of stokers, I was told, 740 long tons could be burned in a week of six days. I was informed that coal has never been used to assist combustion.

*These figures are from "The Municipal Year Book" for 1904 (London).

There are one charger or top man and two stokers to each eight-hour shift. The three chargers receive 24 shillings each, or $5.83 a week, and the six stokers 28 shillings, or $6.80 a week. This makes a total of £12, or $58.30 per week. On the basis of 480 long tons per week, the labor cost, as reckoned at the plant, would be about 6 d., or 12 cts., per ton. It will be noted that the labor cost does not include either the engineman or the foreman, but labor costs at most, if not all destructors in England appear to be figured in the same way. That is, they include chargers and stokers only. In this particular case the foreman has charge of the refuse collection for the whole district tributary to the destructor, and all his wages are charged to collection.

I visited the works on April 12. The refuse which I saw was mostly ashes. I was told that scarcely any green stuff comes to the wharf, and that even in summer it is only some 5% of the total collections. No odors were noticed. The chimney was giving out a little light smoke. Mr. James Thomas Law is foreman of the destructor and of the collection district.

DESTRUCTORS COMBINED WITH SANITARY MANURE WORKS AT ROCHDALE.

Some of the refuse of Rochdale is screened and the more combustible screenings are utilized to supply heat for the sanitary manure works, or plant employed to convert night-soil into a marketable fertilizer. Since 1894 such of the refuse as is not screened has been burned in a refuse destructor and the heat has been utilized for works purposes. This destructor was among the earlier to produce high pressure steam, and by example did much to introduce power production from refuse on a large scale and for other than destructor works purposes.

Rochdale now has a population of about 84,000. Mr. S. S. Platt, M. Inst. C. E., has been borough surveyor since 1881, and for many years Mr. F. W. Brookman has been manager of the sanitary manure works and, later, of the refuse destructor. Mr. J. H. Heywood is assistant to Mr. Brookman, and in the absence of both the other gentlemen named, Mr. Heywood showed me about the combined works on April 14, 1904.

The night-soil or sanitary manure works date from 1869. As now operated, the night-soil is evaporated by means of revolving cylinders, followed by drying plates. The heat for drying is generated in five Cornish boilers, placed end to end and connected with the revolving cylinders. From the cylinders the partly dried night-soil, about the consistency of thick mud, is removed to drying plates, beneath which are passed the partly spent gases from the cylinders. The gases are then sent through a spray washer and through a condenser and to a furnace. The draft through the cylinders and in the chimneys is increased by means of a Root's exhauster.

The refuse destructor is described as of local design, fitted with Meldrum's steam jet blowers and grates. There are two large cells, fed from the front, with grates 9 ft. long and 5 ft. deep, having the space beneath each grate divided into two ashpits. This permits keeping one side of the fire at a high temperature while the other side or end is being charged or clinkered. A large combustion chamber back of the grate serves as a mixing chamber for the gases from both sides of the grate, and thus aids in maintaining a high temperature and complete combustion. Some will recognize these features as identical with the main features of the Meldrum furnace. The Meldrum people claim this as the first of their destructors. Just how the credit for the destructor should be divided between Mr. Brookman and Meldrum Bros., I will not attempt to say. It may be added, however, that Meldrum Bros. were successful boiler manufacturers before they took up refuse destructors, and that the production of boilers is still a large part of their business.

There are two 8 × 30-ft. Lancashire boilers between the destructor cells and the chimney. The latter, which is 250 ft. high, also serves the five Cornish boilers connected with the night-soil dryers.

About 40 long tons of refuse are burned in the cells each day. The clinker has been used for making mortar and also for contact beds at the Rochdale sewage works.

The combination of night-soil works and refuse screening with shovelling the refuse into the furnaces makes this plant dusty and generally disagreeable, but no offensive odors were noted.

The wages paid at the joint works early in 1904 were as follows: Enginemen, 7¼ d., or 14½ cts., per hour; firemen, 6½ and 6 d., or 13 and 12 cts.; riddle or screen men and general laborers, 4½ d., or 9 cts., per hour.

Three tests of the destructor were made in 1895, which are notable because of the high results obtained. A test on March 1 lasted six hours, and tests on Nov. 14 and Nov. 15 lasted 6 hrs each. Some of the results shown, in addition to dates already given, were as follows: Total refuse destroyed, 11.4, 13.75 and 14.3 long tons; refuse burned per sq. ft. of grate surface per hr., 52.6 and 54.9 lbs.; water evaporated to dry refuse (actual and from and at 212° F.) 1.97, 1.39 and 1.68, 1.47 and 1.78; number of boilers used, 2, 1 and 1; temperature of feed water, 53° F., 52 and 52° F.; average steam pressure per sq. in., 113, 113 and 114.* For the test made on March 1, the following additional figures are available: Clinker, 36% of total refuse burned; temperature of combustion chamber (back of grates), 1,988° F., and after clinkering and fresh charging, 1,290° F. Percentage of CO_2 in products of combustion, 15.9; do. of CO, 0; do. free oxygen, 2.2.

THE REFUSE DESTRUCTOR AT THE ALDERSHOT SEWAGE WORKS.

This is a Meldrum front-fed simplex destructor with four grates, having a grate area of 70 sq. ft. It was built in 1900 and the heat from it generates steam to operate sewage pumps which lift an average daily dry weather flow of 600,000 U. S. gallons a distance of 20 ft. Mr. John Edwards, the manager of the combined sewage works and refuse destructor, told me that it is rarely necessary to supplement the refuse with coal.

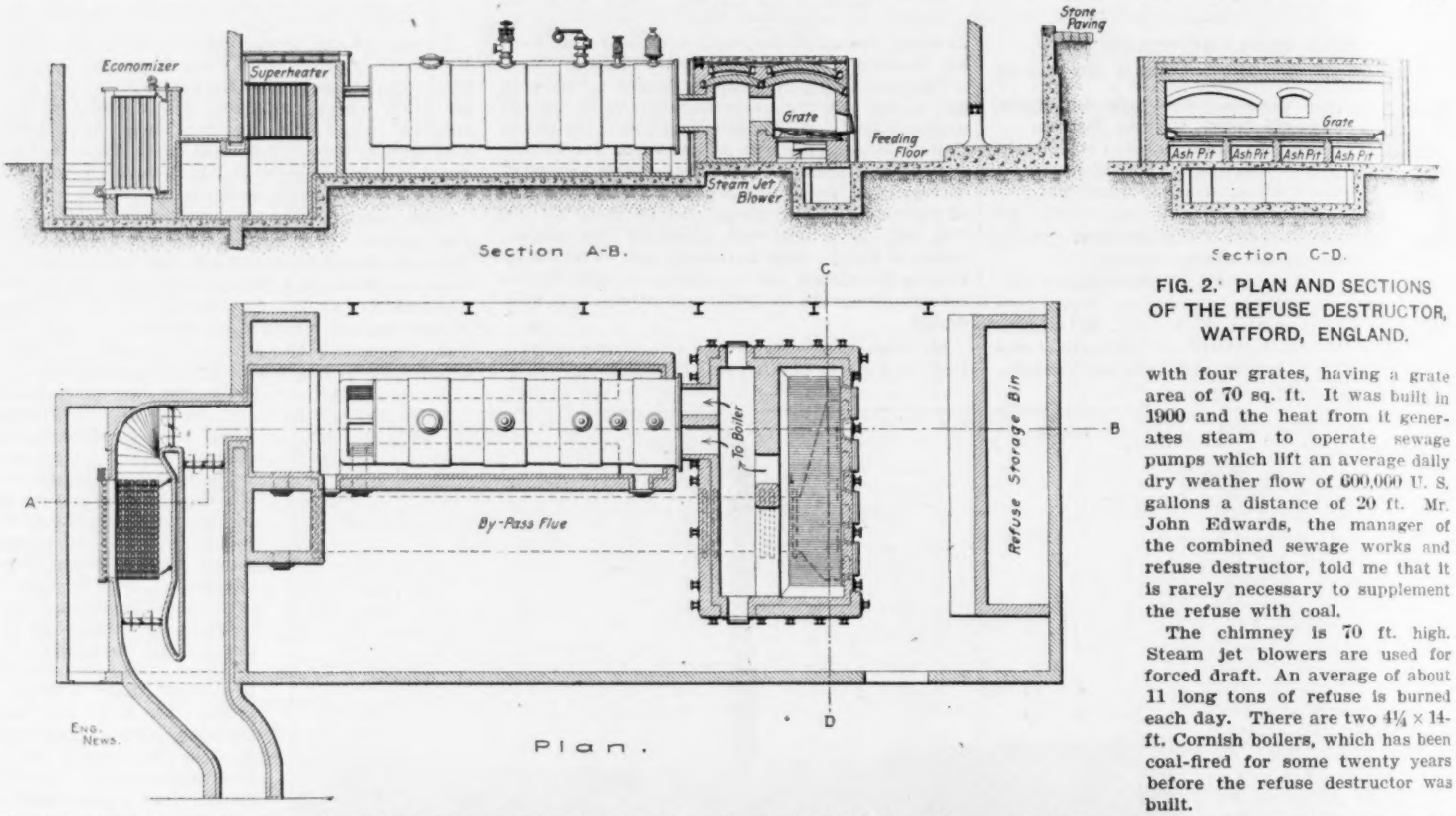


FIG. 2. PLAN AND SECTIONS OF THE REFUSE DESTRUCTOR, WATFORD, ENGLAND.

The chimney is 70 ft. high. Steam jet blowers are used for forced draft. An average of about 11 long tons of refuse is burned each day. There are two 4¼ × 14-ft. Cornish boilers, which has been coal-fired for some twenty years before the refuse destructor was built.

The refuse at the time of my visit was mostly ashes and paper and contained scarcely any vegetable stuff. In summer, I was told, nearly all the refuse is green stuff, but this was the only refuse destructor I saw in Great Britain where so much of what in America is called garbage was reported. I was told, however, that there are many gas stoves in the town. But little smoke was visible at the chimney top.

The clinker from the destructor has been used recently to construct sewage filter beds. It has also been used for road bottoming and for foot paths across fields that are so common and often so pleasant a feature in England.

The destructor is operated whenever the pumps are being run, but the relatively large receiving reservoir renders it feasible to shut down the pumps for about eight hours at night. The force employed at the destructor is three stokers and two enginemen, all at 26 shillings, or $6.32 a week. Two men work Sundays without extra pay, and one man is off duty each Sunday; but as one man leaves early each day they are on the works only 56 hours each per week.

THE REFUSE DESTRUCTOR AT THE SALISBURY SEWAGE WORKS.

The refuse destructor at Salisbury is one of a number in England which are supplying heat to

*These test figures are from Goodrich's "Refuse Disposal and Power Production" (London, 1904).

...team for pumping sewage. Salisbury has ...ulation of about 17,000. When it finally de... to install a refuse destructor, Mr. A. C. ...ms, Assoc. M. Inst. C. E., City Surveyor, ... up a schedule of desired guarantees and ... for bids for a plant which would fill the ...ions indicated. The result was the accept... of bids for a Horsfall destructor, which was ... operation the latter part of 1901.

...e are two cells, side by side, fed from the ... and having about 30 sq. ft. of grate area ... The grates, and the drying hearths behind ... are inclined towards the stoking doors. The ... slide up with the aid of a counterweight.

...ced draft is provided by means of steam jet ...ers. There is a circular dust arrester. The ...mney is of brick and is 120 ft. high above the ...ound level. The base of the stack and also the ... nearly to the top is surrounded by an air space.

There are two 80-HP. Babcock & Wilcox boilers, with provision for independent firing. I saw no coal and was told by Mr. Bothams that none is used except in very wet weather (like the summer of 1903) when the volume of sewage continues high and the quantity of refuse available is relatively small. The boilers have a combined heating surface of 1,800 sq. ft. and carry a pressure of 100 to 110 lbs. A Green's economizer with a heating surface of 720 sq. ft. is used for the boiler feed.

On the 23 hours' contract test of the destructors the following result, as compared with the guarantees, were obtained: Twenty tons of refuse were burned in 19 instead of 23 hours; 39.2 lbs. of refuse per sq. ft. of grate surface were burned instead of 32; 1.23 lbs. of water per lb. of coal were evaporated in place of 1 lb.; the maximum furnace temperature was 2,000° F. and the minimum was 1,320° F., instead of 1,800° and 1,200°, respectively, and the average was 1,645° instead of 1,500°. The flue temperature at the inlet to the first boiler was guaranteed to be about 1,600° F., and at the second about 1,400°; the maximum in each case was below the guarantee and the averages were 1,313° and 965°, respectively. The temperature of the feed water on leaving the economizer was guaranteed to average 250°, but only 214° was obtained. These results were overlooked since all the other guarantees had been exceeded.

About 120 tons of refuse are collected each week, arranged so as to distribute it well through the week and leave some extra for keeping up the fires and for pumping on Sunday. The average daily quantity of sewage pumped is given as 3,600,000 U. S. gallons and the lift is 15 ft.

The labor at the refuse destructor, pumping station and sewage works is interchanged, but is estimated to cost about $6,000 a year, including repairs. Three engineers at 32 shillings, or $7.78, each per week, and three stokers at 24 shillings, or 5.83, per week, are employed, all on eight-hour shifts, and there is one stop-gap man, who serves as either engineer or stoker and who makes needed repairs. Laborers are paid 19 to 24 shillings, or $4.62 to $5.83, a week for a working day of 11 to 12 hours. The manager for the combined works lives in a cottage on the spot, and thus is always on call. He is paid £2¼, or $10.93 a week. Mr. John Hamlin is manager of the works, and has been in the employ of the city for about twenty-five years.

In common with the many other British refuse destructors which I have visited, this one is substantial in construction. The inclined roadway is a solid earth embankment, instead of the wooden trestle and floor so common in America, and the building is of brick, instead of a mere shell of corrugated iron.

THE UTILIZATION OF DESTRUCTOR HEAT FOR PUMPING SEWAGE AT WATFORD.

It is customary in England to have a formal opening of important public works, and it was my good fortune to attend one of these at Watford. This particular opening was to celebrate the completion of a refuse destructor, the heat from which is being utilized to pump the sewage of the town to a sewage farm.

Watford is a London suburb of some 30,000 inhabitants. Mr. Edward Kingham is chairman of the urban district council, and a lunch was given in his name in honor of the destructor opening. Mr. D. Waterhouse is district surveyor.

The destructor is of the front-fed type, and were erected by Meldrum Bros., of Manchester. There are four grates with one common cell above, but separate ashpits below. This cell is 6

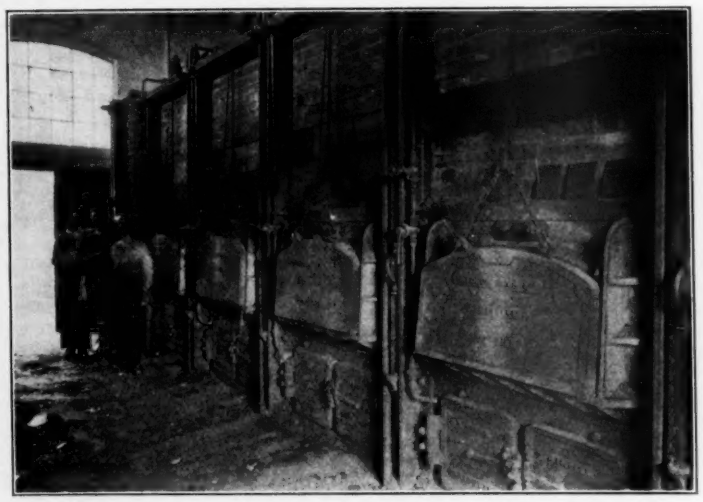


FIG. 3. FRONT VIEW OF REFUSE DESTRUCTORS, WATFORD, ENGLAND, SHOWING FEED AND ASH PIT DOORS.

ft. 2 ins. × 22 ft. over all, in plan, and the total grate area is 100 sq. ft. The grates have a slight inclination towards the front and the grate bars are of iron. The separate ashpits permit feeding and clinkering each grate without checking the whole fire by a rush of cold air. The rated capacity of the destructor is 40 long tons in 24 hours. The gases of combustion pass to and are mixed in a combustion chamber, back of and parallel to the cells, and then pass on to the boiler.

The 8 × 30-ft. Lancashire boiler supplies steam for the steam jet blowers used to produce forced draft and also to the sewage pumping station, some 90 ft. distant. The average daily amount of sewage pumped was given as 1,250,000 Imp. or 1,500,000 U. S. gallons. At the time of my visit the pumps (two Worthington triple expansion) were working under a total head of 58 ft. and the boiler pressure was 117 lbs.

Beyond the boiler there is a regenerator which utilizes some of the heat to raise to some 300° F. the temperature of the air supplied for forced draft, and beyond the regenerator there is a Green's economizer for heating the boiler feed water. The air supply for the regenerator is drawn from the building, thus aiding ventilation. The feed water entering the economizer has already been raised to a temperature of about 150° F., it is said, by means of a Boby "heater detartarizer" or feed water heater, supplied with exhaust steam from the pumping engines.

The chimney is 170½ ft. high above the level of the ground, and has a flue 9 ft. in diameter at the base and 5¾ ft. at the top. The chimney was built by the Custodis Chimney Co.

The destructor is housed by a stone building with an iron roof, the latter slated outside and ceiled with wood inside. The feeding and clinkering floor is paved partly with stone and partly with concrete. The earth ramp or inclined roadway is paved with stone. The main building is about 34 × 79 ft., inside the walls, besides which there is a low addition, covered with corrugated iron, to house the economizer and other accessories.

The refuse is dumped from the ramp into a storage bin, formed by building a wall across the end of the building 6 ft. from the outer wall, and 11½ ft. from the feed doors of the cells. An opening some 2 ft. high at the bottom of the wall permits the refuse to fall onto the feeding floor.

No provision for utilizing the clinker had been made at the time of the opening, but it was expected that it could be used for road and mortar making or sold to sewage works for making filter beds.*

The refuse which I saw was practically all ashes and paper.

The same delays in securing sanitary improvements seem to be experienced the world over. Mr. Waterhouse recommended a destructor in 1893, but it was not put under construction until 1903. Meanwhile a huge pile of refuse accumulated near the site afterwards adopted for the destructor. In 1900 an outbreak of diphtheria in houses near the refuse heap was seized upon by the medical officer of health as an argument for building a destructor. A plague of flies and rats, bred at the dump, was a far more reasonable, if not more convincing, argument.

The destructor was located close by the combined sewage pumping and electricity works, but was provided with a separate chimney. The quantity of refuse being collected at the close of March, 1904, was about 23 long tons a day, and as some 40 long tons are needed to raise sufficient steam to pump the sewage, the old refuse heap was to be drawn upon to make good the deficiency.

The cost of the destructor and accessories, chimney and building, was about £6,800, or $33,066, divided as follows: Destructor, boiler and accessories, £3,495, or $16,985; economizer, £300, or $1,458; building, £1,218, or $5,919; chimney, £1,283, or $6,235; tipping platform, £503, or $2,469. These figures include nothing for land, which was already owned by the town.

The average annual cost of pumping the sewage with coal for fuel during the three years befor installing the refuse destructor was given at the time of the destructor opening as follows: Coal, £890, or $4,325; firemen, £125, or $608; total, £1,015, or $4,933. The cost of refuse disposal at the tip was £52, or $253, per year for wages and disinfectants, which added to the cost of pumping made £1,067, or $5,186, for maintaining the refuse tip and pumping the sewage before the destructor was established.

The annual cost of operating the destructor, it was expected at the time of the opening, would be: Interest and sinking fund, £460, or $2,235; labor in handling refuse (estimated), £410, or $1,993; repairs (estimated), £100, or $486; total, £970, or $4,714. This shows an apparent saving by the change of £97, or $472, with no allowance for the possible revenue from clinker or, on the other hand, with no debit allowance for its disposal in case there was no demand or only a partial demand for it.

The destructor was guaranteed to burn 40 long tons of refuse in 24 hours, and to evaporate 1 lb. of water to 1 lb. of refuse. On a nine-hour test† both these guarantees were exceeded by somewhat over 50%. The refuse delivered amounted to 55,517 lbs., including 1,295 lbs. of tins, pots and the like, or 2.33% of the total. The amount burned in the nine hours was 54,222 lbs., or 60.32 lbs. per sq. ft. of grate surface. Each grate was clinkered five time during the test, requiring 7.63 minutes each time. The clinker was 25.84% of the refuse burned.

The actual evaporation, with the aid of the economizer, was at the rate of 1.29 lbs. to 1 lb. of refuse, while from and at 212° F. the evaporation was at the rate of 1.56 lbs. The feed water entered the economizer at 53° F. and left it at an average of 243.2° and a maximum of 322° F.; but the economizer by-pass damper was open half way throughout the test, since the station regulations do not allow a feed water temperature of more than 300° F. at the economizer outlet.

The maximum temperature in the combustion

*On June 18, 1904, Mr. W. F. Goodrich, Assoc. Inst. M. E., wrote to me that the clinker was selling freely at 2 s. 8 d., or about 65 cts. per long ton, and that a two-year contract had been made for the sale of the tins, etc., from the refuse at the rate of 14 s. 9 d., or $3.58, per long ton. The prices in each case are for the material loaded into trucks or cars on the railway siding at the destructor. It appears that the clinker, at the date named, was being sold for use in sewage filter beds.

†The results of the test have been taken from the "Public Health Engineer" (London) for Aug. 27, 1904.

chamber of the destructor, which is back of the grates, was reported as 2,700° F. and the "average approximate temperature" as 2,000°. The temperature of the gases in the boiler downtake was 1,500° maximum; 800° minimum; 1,106° average. At the chimney base the temperatures were 455°, 300° and 409°, maximum, minimum and average. The average ashpit pressure was 1.1 ins. and the maximum was 3 ins. The pulls at the chimney base were 1.12, 1 and 1.03 ins., maximum, minimum and average.

THE PROPORTIONS OF INGREDIENTS IN PORTLAND CONCRETE.*

By Richard T. Dana,† Assoc. M. Am. Soc. C. E. M. Am. Inst. M. E.

We are accustomed to think and write of "one, two, five," or "one, three, six" concrete without always specifying whether the "one" means cement just before or just after coming out of the barrel. This is unquestionably bad practice, and it is unfair both to the contractor and to the engineer's employer, for the difference between the volume of the packed and the unpacked cement amounts to just about 35%, and some one pays for it.

The object of writing specifications is two-fold: (1), to inform the contractors exactly what kinds and proportions of work and materials they are to furnish; and (2), to compel the successful bidder to live up to his contract, which should not mean, "do just what the inspector says, no matter what it costs, and guarantee the results." As concrete specifications are ordinarily written today, they fail signally to fulfil the first of these requirements, and they fail considerably short of meeting the second.

The contractor generally furnishes his own stone and sand, and neither he nor the engineer in charge knows the percentages of voids. Here is where the lottery comes in. If the proportions of cement and stone are not given in the specifications, the contractor is all at sea on his bid. If they are given (as a more or less accurate guess) the engineer's employer gets a mixture of doubtful efficiency and generally at a higher price than necessary. Otherwise, after the work is started, there is an adjustment of proportions and shattering of friendships between the engineer and contractor.

It is believed that the accompanying diagrams will offer a means of avoiding some of these vexatious misunderstandings, and, when properly used, insure a better grade of mortar and concrete at a considerable reduction in cost from that attendant upon the ordinary methods.

The assumptions of the theory are as follows:

(1) The voids in the sand should be filled with cement paste.

(2) The voids in the stone or gravel should be filled with mortar.

(3) There should be a small and definite excess of mortar over the amount necessary to fill the voids in the sand.

(4) Likewise there should be a small and definite excess of mortar over the amount necessary to fill the voids in the stone.

(5) The voids in the sand and stone are easily determinable. And the voids of the stone after being rammed can be determined before addition of mortar with sufficient accuracy for all practical purposes, any error here being on the safe side.

(6) The excess of cement serves the two-fold purpose of compensating for irregularities in mixing, preventing accidental voids, and of supplying a coat of cement over the surface of each grain of sand and piece of stone. A larger excess of cement accomplishes no useful object, makes the concrete more liable to cracks and checks, and, in general, reduces the density of the mass, besides adding greatly to the cost of the work.

Let C equal the volume of cement paste in a unit volume of concrete.

Let S equal the volume of sand.
" G " " " " stone or gravel.
" V " unit volume of the finished concrete.
" a " percentage of voids in stone or gravel.
" b equal percentage of voids in sand.

*Copyright, 1905, by Richard T. Dana.
†15 William St., New York.

(1) Then G (1—a) equals net volume of stone.
(2) " S (1—b) " " " " sand.

Then, if all voids are filled (a condition never quite fulfilled in practice),

(3) V equals C + G (1—a) + S (1—b).
Sb " volume of voids in the sand.
Ga " " " " " " stone.

Now, in order exactly to fill the voids in the mortar, C must be Sb. (4) But, allowing a percentage of excess, E, C = (1 + E) Sb. From (2) the total volume of the mortar is C + S (1—b). Substituting (4), Mortar equals Sb (1+E)+S (1-b.)

" Sb + ESb + S-Sb
(5) " S (1 + Eb)

Now, in order just to fill the voids in the stone, this quantity should equal Ga, but, allowing a percentage of excess, E, (which may be taken as the same as in the case of the cement and sand), we have

(6) Ga (1 + E) = S (1 + Eb).

Also net volume plus mortar equals V, or

(7) G (1 − a) + Ga (1 + E) = V.

Clearing of brackets, G (1 + aE) = V.

(8) $G = \frac{V}{(1 + Ea)}$ from (7).

(9) $S = \frac{Ga\,(1 + E)}{(1 + Eb)}$ from (6).

Now the ratio of sand to cement is equal to $\frac{S}{C}$, and the ratio of stone to cement is equal to $\frac{G}{C}$.

$\frac{S}{C} = \frac{Ga\,(1 + E)}{(1 + Eb)\,(1 + E)\,Sb}$, from (4) and (9).

(10) Substituting (6), $\frac{S}{C} = \frac{1}{b\,(1 + E)}$.

Also, $\frac{S}{G} = \frac{a\,(1 + E)}{(1 + Eb)}$, from (9).

And $\frac{C}{S} = (1 + E)\,b$, from (4).

Multiplying these two equations together, we have

(11) $\frac{C}{G} = \frac{ab\,(1 - E)^2}{(1 + Eb)}$.

These equations (10) and (11) will give the relative quantities of sand and stone in concrete, the amount of cement paste being taken as ...lity. Equation (8) gives the amount of stone ... unit of concrete, and from it the amount of ...ent paste is determinable.

These expressions, for different values ... b, and E are plotted on the accompanying di... ms, from which can be read at once the pro... ons necessary for any given quality of conc... and percentages of voids. The extreme ston... ues given in the diagrams, when the stone ... are 35% and the cement voids 15%, will ... be arrived at in practice, but the diagram... t be used with perfect confidence and with ...lute assurance that the voids will be filled ...ded that the voids in the sand and stone are ...perly determined in the first instance. It will ...noted that the voids in the stone are supposed ... the same in the first determinations as after ...ing in the mortar. No allowance has been made for consolidation by ramming. This does not mean that ramming is unnecessary.

It is the writer's practice to mix the concrete with enough water to make it just quake under ramming, and then to ram rapidly and briefly. For watertight work slightly more water is added.

Attention is called to the long sand line. Frequently stone is not available or is very expensive, when gravel is cheap and plentiful. By mixing gravel from two parts of the bank, the voids can often be reduced to 15% or 20%. With E equal to 10% this makes splendid concrete, mixing in the cement directly, from 1-4-5 to 1-6, and, by stretching a point, even higher. A large proportion of the writer's concrete work of late years has been with sand and gravel alone, stone costing from $1.50 to $2.00 per yard on the work, and cement from $1.25 to $1.75 per bbl.

For purposes of estimation, the writer classifies concrete by the value of E, and in writing specifications and in the field uses the ordinary nomenclature of sand and stone, the values being taken from the diagrams.

It will be noted that the voids in sand do not run above 42% in the diagrams. Frequently the first test of sand will show 45% or 50% voids, but this can nearly always be reduced by mixing two kinds of sand, which is more economical than using the extra amount of cement involved.

The number of cubic feet of cement paste which can be obtained from a barrel of cement depends upon a number of factors, the thoroughness of ramming, the voids in the cement itself, amount of water used, etc. The value given, 3.5 cu. ft.,

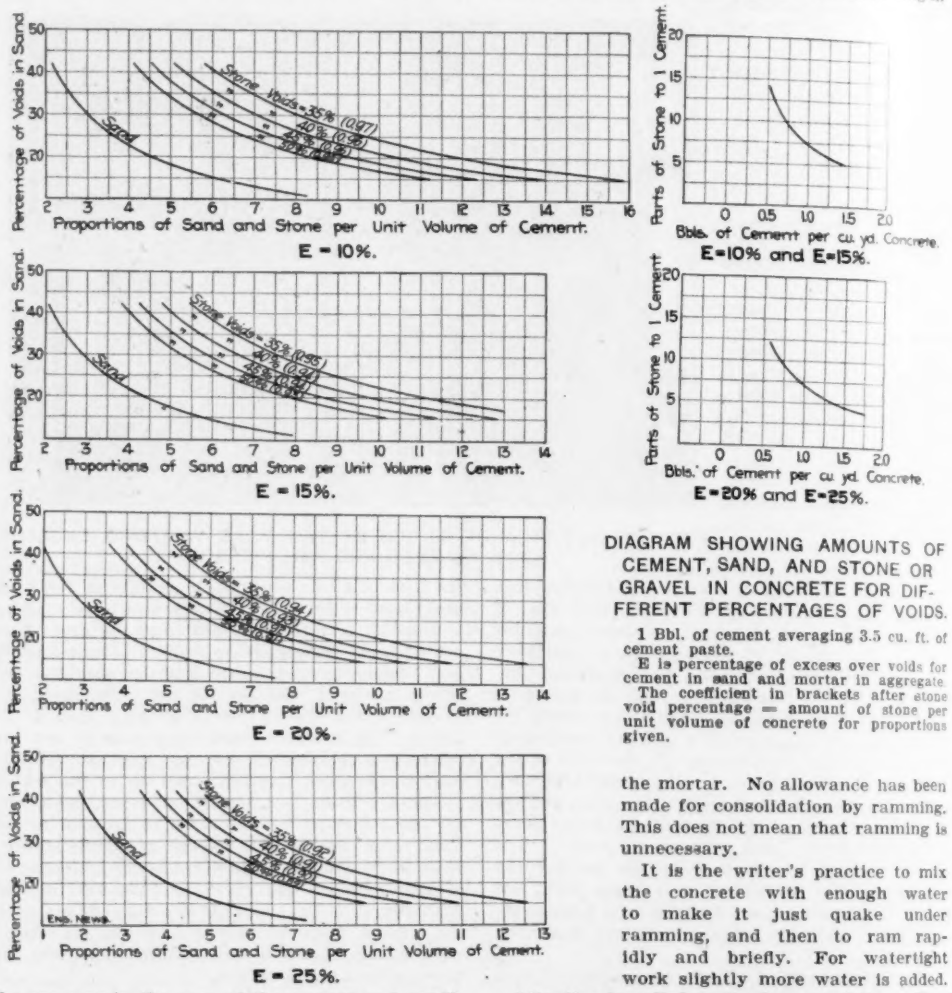


DIAGRAM SHOWING AMOUNTS OF CEMENT, SAND, AND STONE OR GRAVEL IN CONCRETE FOR DIFFERENT PERCENTAGES OF VOIDS.

1 Bbl. of cement averaging 3.5 cu. ft. of cement paste.
E is percentage of excess over voids for cement in sand and mortar in aggregate.
The coefficient in brackets after stone void percentage = amount of stone per unit volume of concrete for proportions given.

which best accords with the writer's experience, and is, if anything, on the "safe side."

For foundations 10% concrete is recommended.

For abutments and piers, 15% concrete is recommended.

For reinforced work, 20% concrete is recommended.

For thin sections, slabs, and waterproof work, 25% concrete is recommended, with an excess of sand.

The voids in the stone can easily be obtained by measure in the field, but the sand voids are difficult to obtain because with damp sand there are air bubbles within the mass that prevent the entrance of water into all the voids. A method that has been much recommended is to weigh a cubic foot of sand and figure out the voids by means of the specific gravity of quartz, 2.65, or 165 lbs. per cu. ft.

The best method known to the writer is as follows: Take a quart measure exactly half full of water, and pour into it exactly one pint of the dry sand. If the water rises to the first gill mark from the top the voids are 25%; if 1½ gill marks from the top, voids are $\frac{1.5}{4} = 37.5\%$, and so on.

To illustrate the use of the diagrams. Suppose that we wish to make foundation concrete, and find the voids in the stone and sand 45% and 33⅓ respectively. Then, assuming E equals 10%, by the diagram the proportions by volume are 1:2.75:5.75.

For a check, the voids in 2.75 volumes of sand are

2.75 × 0.33 equals	0.91
E equals 10%	0.09
Amount of cement paste required	1.00,

which checks.

Also, the net volume of sand is 2.75 − 0.91 equals 1.84 vols.

add cement paste	1.00
Voids in stone plus 10% E equals	2.84
Therefore, voids in stone equal $\frac{2.84}{1.1}$ equals	2.58
Stone equals $\frac{2.58}{0.45}$ equals	5.75 vols.

which checks with the diagram.

We wish now to get the number of barrels of cement per cu. yd. of concrete. On the small diagram, corresponding to the 5.75 ordinate, we have the abscissa 1.28, or practically 1.3. Had we taken E equals 20%, with the same voids we should have had 1:2.5:5 concrete and 1.40 bbls. per yard.

The amounts of stone per cu. yd. of concrete are 0.96 and 0.92, found in brackets on the stone line of the diagrams. The values were obtained by equation (8), and check with practice.

Take the data of the first example and suppose there is a gravel bank available not more than ¼ mile from the work. We can get screened gravel delivered for, say 50 cts. per cu. yd. on the wagon. Mix ¼ cu. yd. of this gravel having say 35% voids, with every yard of the stone. Then in every cubic yard of stone there will be:

Voids	0.45 cu. yd.
Net stone	0.55 " "
Gravel	0.25 " "
Voids in gravel .25 × .35	0.088 " "
Net vol. gravel	0.162 " "
Gross vol. of stone and gravel, say 1.05	" "
Voids in stone and gravel, 1.05-0.71	0.34 " "

Voids = 0.34 ÷ 1.05 = 32.4%, or say 35%. Our mixture with the same sand then becomes 1:2.75:7.4, instead of 1:2.75:5.75, and the cement per yard is reduced from 1.3 bbls. to 1 bbl. per yard of finished concrete.

The cost of the screened gravel has been $\frac{.97}{4} \times 50$ cts. or 12.1 cts. The extra labor of mixing will on the most liberal estimate not be more than 10 cts. per yard. The saving in cement will be 0.3 bbl. per yard, or, if the cement cost $1.50 per bbl. on the work, 45 cents—a net saving to somebody of 32.9 cts. per yard of concrete. On a thousand yard job this is a saving of $329 at an expenditure, on the part of the engineer, of an hour's time and a little gray matter. On a ten thousand yard job the saving is no small item, and even on a small piece of work the saving pays the cost of the engineer's time many fold. Bear in mind that the mortar is just as rich at it was before, and that the resulting concrete should be just as strong. These figures are finely drawn, but they are well within the limits of practice.

The diagrams also give an idea of some of the pitfalls attending the use of our old standby's, the 1:2:5 and 1:3:6 mixtures, without first ascertaining the voids. The 1:2:5 mixture contains an unnecessarily large amount of cement in the mortar and too much stone where the sand voids are 34% or less. The 1:3:6 mixture is all right for 30% sand and 47% stone, but for 35% stone 8 parts may be used, E being 10%.

There were some very interesting experiments by Prof. C. E. Sherman, published in Engineering News, Nov. 19, 1903, from which it was shown that with 1:3 mortar (by weight) an addition of 15% of loam or clay to the sand gave an actual large increase of strength to the mortar. The inference is that dirt, or loam, or clay in the sand to the extent of 15% is a benefit and not an injury to the mortar.

Without going at present into an analysis of Prof. Sherman's figures it can, I think, be shown that the gain in strength is directly attributable to the fact that the clay or loam simply filled up the voids, and, although the quantity of cement was not increased, the efficiency of it was increased most decidedly. This is exactly in line with the writer's contention that in all concrete it is not only desirable but economical to fill the voids just as much as possible. There will be some in the cement paste under the very best of conditions, but the amount should be reduced to the very minimum by proper methods of mixing, ramming and, not least, proportioning.

It is gradually but surely becoming impressed upon the engineering profession that we have been ignoring the fact that our pet "one, three" mixture in reality contains a large excess of voids, and that if instead of reducing these voids by means of clay or loam, or just dirt, we use another size of sand from the same bank, we will get a stronger and more reliable mortar at the same or a slightly higher price. The dirt, in the writer's opinion, is a distinct disadvantage, but call it adulterant of the cement instead of giving it the dignity of sand.

It should be noted that an excessively fine sand, or a large number of very small stones in the concrete, when the amount of cement per cu. yd. is less than 0.9 bbl., will affect the economical value for E., and the difficulty of mixing. The unit of dry cement above taken is the *packed* unit and weighs about 108 lbs. per cu. ft.

THE NEW BRITISH REGULATIONS FOR THE USE OF HEAVY MOTOR VEHICLES.

In both England and France the use of heavy freight vehicles propelled by mechanical traction has now assumed such large proportions that the resulting wear of the roads has become a very serious matter. It is coming to be clearly understood that there are certain definite limits of unit pressure which may not be exceeded by wheels rolling on paved surfaces without rapid destruction of the paving. In the development of freight automobiles, however, the tendency is to seek economy by building vehicles of very large capacity, regardless of the effect on the roads and paving.

In response to the general complaint of highway surveyors and taxpayers, the Local Government Board of Great Britain has recently established a set of rules limiting the weight of motor vehicles and fixing the width of tire in proportion to the weight and the wheel diameter. The rules are excessively complicated, and would appear to be clumsy and awkward in operation. They represent, however, the first official action, so far as we recall, to protect public roads from injury by the use of motor vehicles; and we have, therefore, deemed it worth while to reprint them, somewhat condensed by omitting some legal verbiage.

It may be noted that these new rules went into effect on March 1, 1905. They are in substance as follows:

In the Regulations—

The expression "heavy motor car" means a motor car exceeding two tons in weight unladen.

The expression "trailer" means a vehicle drawn by a heavy motor car.

The expression "registering authority" means, in relation to a heavy motor car, the Council of a County, or the Council of a County Borough.

The expression "axle-weight" means, in relation to an axle of a heavy motor car, or of a trailer, the aggregate weight transmitted to the surface of the road or other base whereon the heavy motor car or the trailer moves or rests, by the several wheels attached to that axle when the heavy motor car, or the trailer, is loaded.

The expression "registered axle-weight" means, in relation to an axle of a heavy motor car, the axle-weight of that axle, as registered by the registering authority in pursuance of the Regulations.

The expression "weight" in relation to a heavy motor car or trailer when unladen, means the weight of the vehicle exclusive of the weight of any water, fuel, or accumulators used for the purpose of propulsion.

ARTICLE III.—Notwithstanding anything in the Motor Car Acts, 1896 and 1903, and except as is otherwise provided in the Regulations, a heavy motor car may be used on a highway if the weight of the heavy motor car unladen does not exceed five tons, or if the weight of the heavy motor car unladen with the weight of an unladen vehicle drawn by it does not exceed six and a half tons.

ARTICLE IV.—(1) On every application to a registering authority for the registration of a heavy motor car, the owner shall declare—

(a) The weight of the heavy motor car unladen,

(b) The axle-weight of each axle, and

(c) The diameter of each wheel.

(2)—(a) Before a heavy motor car is registered, the weight of the car unladen, and, if the registering authority so direct, the axle-weight of each axle of the car, shall be ascertained by or in the presence of an officer of the registering authority. That officer shall certify the weight or weights so ascertained, and shall make any necessary correction in the statement of weights declared by the owner.

(b) The officer of the registering authority shall also satisfy himself that the tires of the wheels of the car, if the tires are not pneumatic, or are not made of a soft or elastic material, are of the dimensions required by the Regulations.

(c) The owner of a heavy motor car shall, for the purpose of this condition, cause the motor car to be driven or brought to any such place as the registering authority appoint.

(3) Upon the registration of a heavy motor car,—

(a) The weight of the heavy motor car unladen, as certified as aforesaid,

(b) The axle-weight of each axle,

(c) The diameter of each wheel,

(d) The width and material of the tire of each wheel, and

(e) The highest rate of speed at which, in conformity with the Regulations, the heavy motor car may be driven without a trailer,

shall be entered in the Register of Motor Cars.

(4) Upon receiving from the registering authority a copy of the entries made in the Register relating to a heavy motor car, the owner of the heavy motor car shall cause—

(i.) The registered weight of the heavy motor car unladen,

(ii.) The registered axle-weight of each axle, and

(iii.) The highest rate of speed at which, in conformity with the Regulations, the heavy motor car may be driven without a trailer,

to be painted, or otherwise plainly marked, in the first and second case upon some conspicuous part of the right or off side of the heavy motor car, and, in the third case, upon some conspicuous part of the left or near side of the heavy motor car.

The owner of the heavy motor car shall cause the aforesaid particulars to be painted or marked in letters and figures not less than one inch in height, and of such shape and color as to be clearly legible and clearly distinguishable from the color of the ground whereon the letters and figures are painted or marked; and he shall cause all the paint or marking to be from time to time repaired or renewed as often as may be necessary to keep the said letters and figures clearly legible and clearly distinguishable.

ARTICLE V.—(1) The axle-weight of an axle of a heavy motor car shall not exceed the registered axle-weight.

(2) The registered axle-weight of an axle of a heavy motor car shall not exceed eight tons, and the sum of the registered axle-weights of all the axles of a heavy motor car shall not exceed twelve tons.

ARTICLE VI.—(1) The tire of each wheel of a heavy motor car shall be smooth, and shall, where the tire touches the surface of the road or other base whereon the heavy motor car moves or rests, be flat;

Provided that the edges of the tire may be bevelled or rounded to the extent in the case of each edge of not more than half an inch:

Provided also that, if the tire is constructed of separate plates, the plates may be separated by parallel spaces which shall be disposed throughout the outer surface of

the tire so that nowhere shall the aggregate extent of the space or spaces in the course of a straight line drawn horizontally across the circumference of the wheel exceed one-eighth part of the width of the tire.

(2) The width of the tire of each wheel of a heavy motor car shall be determined by such of the following conditions as may apply to the circumstances of the case; that is to say,—

(a) The width shall in every case be not less than five inches.

(b) The width shall be not less than that number of half inches which is equal to the number of units of registered axle-weight of the axle to which the wheel is attached.

The unit of registered axle-weight shall vary according to the diameter of the wheel, and the rules set forth in the subjoined scale; that is to say,—

(i.) If the wheel is three feet in diameter, the unit of registered axle-weight shall be seven and a half hundredweights;

(ii.) If the wheel exceeds three feet in diameter, the unit of registered axle-weight shall be seven and a half hundredweights, with an addition of weight in the proportion of one hundredweight for every twelve inches by which the diameter is increased beyond three feet; and in the same proportion for any increase which is greater or less than twelve inches; and

(iii.) If the wheel is less than three feet in diameter, the unit of registered axle-weight shall be seven and a half hundredweights, with a deduction of weights in the proportion of one hundredweight for every six inches by which the diameter is reduced below three feet; and in the same proportion for any reduction which is greater or less than six inches.

(3) This article shall not apply to any tire which is pneumatic or which is made of a soft or elastic material.

ARTICLE VII.—The speed at which a heavy motor car is driven on any highway shall not exceed eight miles an hour:

Provided that—

(a) If the weight of the heavy motor car unladen exceeds three tons; or

(b) If the registered axle-weight of any axle exceeds six tons; or

(c) If the heavy motor car draws a trailer,

the speed shall not exceed five miles an hour.

Provided also that—

If the heavy motor car has all its wheels fitted with pneumatic tires or with tires made of soft or elastic material, the speed at which the heavy motor car may be driven on any highway shall not exceed—

(a) Twelve miles an hour—
Where the registered axle-weight of any axle does not exceed six tons; and

(b) Eight miles an hour—
Where the registered axle-weight of any axle exceeds six tons.

ARTICLE VIII.—The diameter of a wheel of a heavy motor car, if the wheel is fitted with a tire which is not pneumatic or is not made of a soft or elastic material, shall be not less than two feet.

ARTICLE IX.—Notwithstanding anything in the Motor Cars (Use and Construction) Order, 1904, a heavy motor car, if its weight unladen is three tons or exceeds three tons, and any trailer drawn by any such heavy motor car may, when measured between its extreme projecting points, be of a width not exceeding 7 ft. 6 ins.

ARTICLE X.—Every heavy motor car shall be constructed with suitable and sufficient springs between each axle and the frame of the heavy motor car.

ARTICLE XI.—(1.) The owner of a trailer shall cause to be painted, or otherwise plainly marked upon some conspicuous part of the right or off side of the trailer, in letters and figures not less than one inch in height, and of such shape and color as to be clearly legible and clearly distinguishable from the color of the ground whereon the letters and figures are painted or marked,—

(a) The weight of the trailer unladen; and

(b) The axle-weight of each axle of the trailer, if the weight of the trailer unladen exceeds one ton.

He shall cause the paint or marking to be from time to time repaired or renewed, as often as may be necessary to keep the said letters and figures clearly legible and clearly distinguishable.

(2) The Regulations, so far as they relate to the width of the tires and the size of the wheels of a heavy motor car, the wheels whereof are fitted with tires which are not pneumatic or are not made of a soft or elastic material, shall, with the necessary modifications, apply and have effect with respect to a trailer exceeding one ton in weight unladen, with the substitution in the Regulations of three inches for five inches as the minimum width of the tires, and of references to the axle-weights painted or marked upon the trailer in pursuance of this Article for references to registered axle-weights.

(3) The axle-weight of an axle of a trailer shall not exceed four tons.

(4) Every trailer shall be constructed with suitable and sufficient springs between each axle and the frame of the trailer.

(5) A heavy motor car which is used either as a stage carriage or otherwise for the conveyance of passengers for gain or hire, shall not draw a trailer.

ARTICLE XII.—If a heavy motor car is upon a highway within a distance not exceeding half a mile by road from a public weighing machine, or other weighing machine which is conveniently accessible, and which belongs to or is subject to the control, or may be used for any purposes of a registering authority or of any other council having control of the highway, and a duly authorized officer of the registering authority or other council has reasonable ground for ascertaining whether the axle-weight for the time being of any axle of the heavy motor car, or of the trailer drawn by the heavy motor car exceeds the registered or marked axle-weight of that axle, the officer may require the person driving or in charge of the heavy motor car to drive the heavy motor car with or without a trailer, or to cause the heavy motor car to be driven with or without the trailer to the weighing machine, and the said officer may then cause the axle-weight for the time being of any axle to be ascertained; and the person driving or in charge of the heavy motor car shall comply withh any such requirement, and shall, to the best of his ability, afford all such facilities as may be reasonably necessary for the purpose of ascertaining the axle-weight as aforesaid.

ARTICLE XIV.—(1) Where any person who is liable to the repair of a bridge forming part of a highway affixes or sets up, in suitable anu conspicuous positions, on the bridge and in each approach to the bridge notices which, as regards all their contents or subject matter, will be clearly and distinctly legible and visible by persons approaching or being on the bridge, and as regards shape, size, color, and all other characteristics will be clearly distinguishable from other notices placed on the bridge, and which state that the bridge is insufficient to carry a heavy motor car the registered axle-weight of any axle of which exceeds three tons or any greater weight which shall be specified in the notices, the owner of any such heavy motor car shall not cause or suffer the heavy motor car to be driven, and the person driving or in charge of the heavy motor car shall not drive the heavy motor car, upon the bridge except with the consent of the person liable to the repair of the bridge.

Provided that where a dispute or difference arises in relation to the insufficiency of the bridge to carry any such heavy motor car, and, on a reference by the person liable to the repair of the bridge and the owner of the heavy motor car, the award or determination of an arbitrator or arbitrators or umpire adjudges the bridge to be sufficient to carry a heavy motor car the registered axle-weight of any axle of which exceeds any weight specified in the notices, this Article shall cease to apply or have effect as regards any such heavy motor car, and the person liable to the repair of the bridge shall forthwith remove every notice affixed or set up in pursuance of this Article.

(2) The owner of a heavy motor car the axle-weight of any axle of which exceeds six tons shall not cause or suffer the heavy motor car to be driven, and the person driving or in charge of the heavy motor car shall not drive the heavy motor car upon a bridge forming part of a highway at any time when another heavy motor car, or a locomotive to which the Locomotives Act, 1898, applies, is on the bridge.

ARTICLE XVII.—The Regulations, in relation to any heavy motor car which belong to his Majesty the King, and is used for the time being, under the care, superintendence, or control of a Secretary of State, for [illegible] purposes, shall apply and have effect—

(a) As if, in Article III. of this Order, [illegible] were substituted for "five tons" and [illegible] were substituted for "six and a half tons"; and

(b) As if, to subdivision (1) of Article VI. of Order were added the following words, [illegible] say,—

"Provided further that if the tire is [illegible] shod or fitted with diagonal crossbars [illegible] conditions of this Article shall for the purpose of determining the width of the tire, apply subject to the substitution throughout those [illegible] of five hundredweights for seven and a half hundredweights as the unit of registered axle-weight."

A NEW COAL-LOADING PLANT AT LORAIN, O.

By W. M. Ray.*

In April, 1902, the Baltimore & Ohio R. R. Co., operating the Cleveland, Lorain & Wheeling Ry., acquired a tract of 42 acres of land on the left bank of Black River, adjoining its yards at Lorain. The company has had at Lorain since 1899 a McMyler side-pump car at Lorain since transfer of shipments of butuminous coal from cars to vessels, and this machine has given satisfaction, having worked up to a capacity of 800 tons per hour. On account of increasing lake business and a desire to have a secondary plant for fueling vessels and to supplement the old machine, in case of a breakdown, it was decided to develop a new dock and plant on the new property.

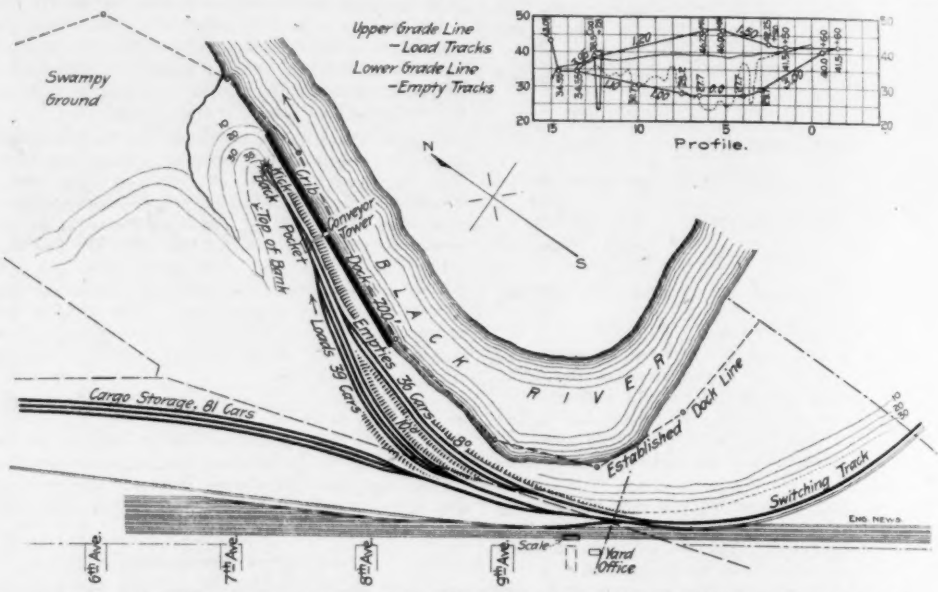


FIG. 1. GENERAL PLAN OF COAL SHIPPING PLANT AT LORAIN, O., B. & O. R. R.

The topography of the tract acquired comprised the usual bluff and swamp to be found at southern lake ports. The bluff forms the bank of the river for about 1,500 ft. from our tracks, presenting 700 ft. of almost straight bank, the crest of which is an elevation of 35 to 40 ft. above the river, with a slope of 1 to 1 or less to the water's edge. Drillings showed the bank to consist of a hard clay resting on disintegrated shale at about 4 ft. above the water, which hardened to solid shale at or slightly below the water level.

A preliminary study for a pocket dock was prepared, which proposed a framed structure to carry tracks over storage pockets at the water edge, to discharge by gravity through inclined spouts into the vessel hatch. This plan was abandoned on account of the extreme height required, with consequent cost of pockets and trestle approach, providing only a temporary structure at best. To discharge into a modern vessel of 54-ft. beam at 20 ft. above water level requires an elevation of the trunnion of the chute of 45 ft., which elevates the tracks to 65 or 70 ft. above the water.

These considerations led to the adoption of a plan comprising:

1. A pocket capacity to exceed the largest coal car.

*Assistant Engineer, B. & O. R. R., Cleveland, O.

A conveyor from a boot at the foot of the ...et to a point on the dock front at the height ...e trunnion for a gravity chute to the vessel ...; the conveyer to be of a capacity to handle ...coal as fast as it can be discharged from cars ...ped one after the other into the pocket.

A gravity chute with telescoping end, such ...s in use on the car unloaders, with the neces...ry power and rig for manipulation.

The dock site presented some peculiar features, ...ich were taken advantage of in construction. ...e shale bottom prevented the driving of piles, ...nd to excavate shale at the foot of the bluff to row of holes. Dredging was completed June 16, 1904.

Prices had been obtained on the different parts of the coal-handling plant, but it was desired to have one concern responsible for the assembling and erection of the machinery, and on Feb. 19, 1904, a contract was closed with the McMyler Mfg. Co., of Cleveland, for the following plant:

A steel-lined pocket, or hopper, of 60 tons capacity;

A conveyor 5 ft. wide with overlapping buckets, by the Link Belt Co., of Chicago, to have a capacity of 650 tons per hour;

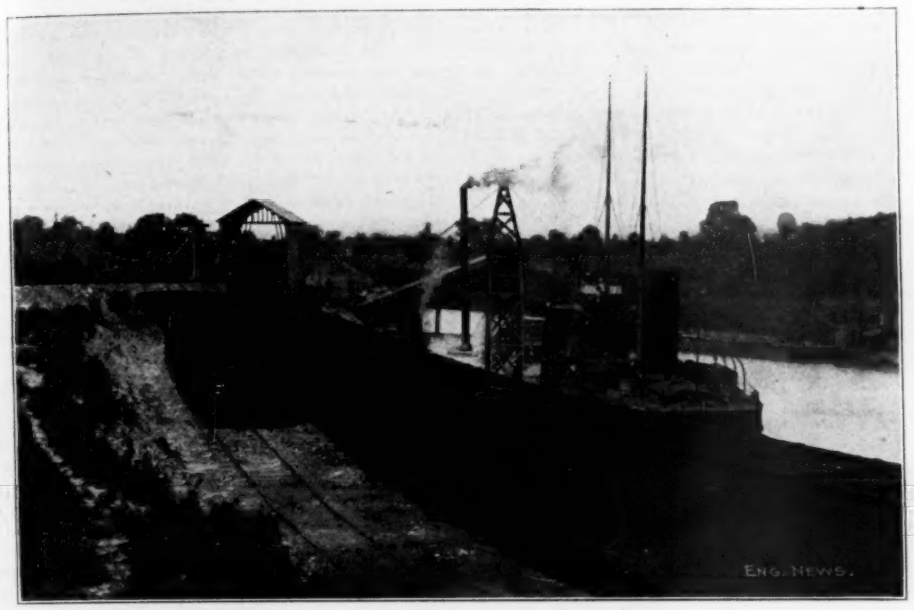


FIG. 2. VIEW OF B. & O. COAL SHIPPING PLANT AT LORAIN. EMPTY CAR TRACK IN FOREGROUND.

a depth of 22 ft. below water for a crib foundation seemed unnecessary. As the dock was to serve only as a landing stage, plans were drawn for a crib to be bedded on the shale just below water line, and required a channel to be cut in the shale along the dock front to the proposed depth of the river, so that the bench on which the crib was built would not be disturbed by dredging. If necessary, this channeled shale face was to be protected by 6-in. sheet piling secured to the crib.

Proposals on these plans were solicited in 1902, but the figures submitted were high, and no contractor was found who would undertake to channel shale to a depth of 22 ft. under water. The matter was allowed to go over until the summer of 1903.

On June 25, 1903, The Standard Contracting Co., of Cleveland, was awarded the contract for the dock and dredging, on their proposition to substitute a row of holes drilled as close as possible for the channel in the shale. Work was begun in September, but little progress was made until late in the fall. A high stage of water prevailing in Black River through the winter of 1903 added much to the difficulty of clearing away the bed for the crib to the proposed depth, and the contractor resorted to the use of a cofferdam, enclosing about 100 ft. of the site at a time, and lowering the water sufficiently by pumping to permit clearing of the site by hand. The crib was completed by April, and the stone filling was in place May, 1904. As soon as the crib was in shape to afford a sufficient support for the machine, a drill was landed from the contractor's drill boat, a scow carrying boiler and air compressor being kept alongside to furnish power, and the drilling of the channel began. With a drill 4 ins. in diameter, it was found impracticable to drill the holes closer than 10 ins. c. to c. The 700 lineal feet of drilling was finished in about 30 working days. The shale dredging was done by a dipper dredge in the usual manner after having been shattered by blasting. There were no indications of disturbance of the bench back of the

A wooden tower at dock to support outer end of conveyor;

An inclined chute with telescoping end;

An 80-HP. horizontal boiler of the Locomotive type;

An Ideal engine, 11 × 10, r. p. m., by A. L. Ide & Sons, Springfield, Ill., 35 HP.

The machinery was erected and ready to run on July 7, but some defects were developed which caused delays, so that the first running test was made on Aug. 2d. It was found necessary to provide an adjustable door at the foot of the pocket. An opening of proper size to load the conveyor with lump coal would overload it when the machine was handling slack coal. The power plant was adequate, but the friction and transmission gears furnished needed to be materially strengthened to carry the loads.

Unfortunately for a satisfactory test of the machine, it was completed at a time when the coal shipments began to fall off and the business could be cared for at the other dock. No ten-hour test has been made as yet, and the gravity yard has not been supplied with cars sufficient for a steady run. However, in a period of forty minutes ten 50-ton cars were dumped and the coal handled at the rate of 750 tons per hour. A car can be dumped and pocket cleared in three minutes.

In connection with this plant, a storage yard with a capacity of 80 cars was built, from which the loaded cars are moved by locomotives to three feed tracks holding 39 cars, which pass by gravity over the pocket, and are returned by kick-back along the front of the bluff to two pocket tracks which hold 36 empties. The Ohio Engineering Co., of Elyria, was contractor for the grading.

Plans for this improvement were prepared by W. B. Hanlon, District Engineer, under J. M. Graham, Chief Engineer of the Baltimore & Ohio Railroad, the writer being Assistant Engineer in charge of construction.

The drawings for assembling the machinery were made by F. W. Lovell, Engineer for the McMyler Mfg. Co.

The machine is operated with ten men at a cost of $560 per month, while the car dump is operated with eleven men at a cost of $750 per month, both exclusive of engine service.

The cost of the improvement is given below. The railroad company's force labored under the same disadvantages as the contractor's in the matter of weather, and much of the track-laying was done during severe cold. A slip on the face of the bluff also added to the expense of constructing the empty tracks, and required the placing of extra anchors to hold the crib dock.

COST OF LORAIN COAL DOCK NO. 2.

Grading:		
13,162 cu. yds., at 33 cts.	$4,343.46	
Extra for blasting frozen ground	339.15	
Extra for timber cribbing	169.62	
Grading by Company force	1,372.42	
		$6,224.65
Track:		
3,488 ft. 85-lb. rail, 7,602 ft. 67-lb. rail: 11,090 lin. ft.		
Materials	$11,776.21	
Labor, track-laying and surfacing	4,616.16	
		16,392.37
Machinery and Structures:		
Pocket, conveyor, bridge, tower chute, power plant and house	$14,117.09	
Trestles	471.49	
Excavation: 1,200 cu. yds.	875.60	
Concrete foundations: 234 cu. yds.	1,353.73	
Tank, stairs, etc.	118.33	
Telephone house	93.38	
		17,029.62
Dock:		
700 lin. ft.		
Excavation, slopes, etc.	$1,522.60	
Stone filling: 2,730 cu. yds.	5,768.00	
Channeling: 700 ft., at $6.50	4,550.00	
	$11,840.60	
Timber: 254 ft. M. B. M., at $35	8,890.00	
Iron: 13,340 lbs. at 4 cts.	533.60	
Iron anchors: 30 at $10	300.00	
13 pile anchors and straps	951.00	
		22,515.20
Total cost for 700 ft.: $32.15 per lin. ft.		
Dredging: 35,982 cu. yds., at 65 cts.		23,388.30
Engineering		2,329.50
Miscellaneous		1,390.09
Total cost of improvement		$80,269.75

THE BURNING OUT OF ELECTRIC STREET-CAR CONTROLLERS.

By Sydney W. Ashe*, B. S.

Why does a street-car controller burn out? This question has frequently been asked the writer. It is not obvious why a controller can be exposed to excess of current when the safety-devices, circuit-breaker and fuse, are in proper condition. There are many trolley cases tried in court in which claimant endeavors to collect damages for an accident occurring during the burning-out of a controller. The railway company usually shows in defence that circuit-breaker and fuse were in normal condition, and that the company therefore was not negligent. This leaves the accident a mysterious occurrence. A discussion of controller burn-outs may therefore be pertinent.

The phenomenon termed "burning-out" usually begins with a rumbling noise, followed almost instantly with a burst of flame from the controller case, accompanied with considerable smoke. The damage which happens to a controller on such occasions varies with the conditions of the equipment at the time of trouble and also depends largely upon where the trouble originates. In a recent case called to the attention of the writer the controller was so much damaged after the burning-out process as to be almost worthless. Many large holes were burned through the controller lid, the controller wiring (insulation) was baked, and the contact fingers and cylinder contacts were badly melted.

The burning out of a controller under ordinary circumstances invariably starts with an arc which jumps to the grounded controller casing, forming a circuit from trolley to ground. The protective devices under these circumstances may be in normal proper working condition, or the circuit breaker may be set high, in which case reliance is placed upon the fuse to protect the circuit. When an arc does jump to the grounded controller casing it may form a direct short circuit or it may form a partial short circuit. In the latter case it would obviously have to form between a resistance finger of the controller and the casing, in which case the magnitude of the arc following the grounding of the circuit would depend upon the

*Instructor, Polytechnic Institute of Brooklyn, New York, N. Y.

amount of the series car resistance forming a part of the circuit. It seems quite possible in such a case, the line pressure being 500 volts, for an arc of 175 amperes to continue. This arc would gradually melt the contact fingers and casing until a direct ground had been formed. The current flow would then be in excess of 175 amperes and a circuit breaker set for 250 amperes would open instantly. It is obvious, however, that the duration of such a burning-out process would be sufficient to severely damage the controller. Also, the fuse

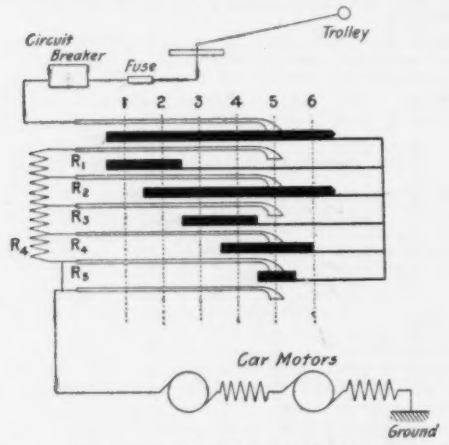


Fig. 1. Diagram of Street-Car Controller Wiring, with Controller Handle in Position 5.
(Reverser and Lower Part of Controller Contacts Omitted.)

and circuit breaker could be in normal condition and still the controller burn out if an arc were to form in such a manner.

As an illustration, suppose an arc were to form between contact finger R_5 and the controller cylinder as the controller was being turned off; and suppose also that this arc should jump to the grounded casing of the controller. When the arc is in a transition period in jumping to ground, that portion of it coming from the controller cylinder is extinguished by the blow-out magnet. However, the other portion of the arc would strike to ground, forming a circuit from the trolley to resistance R_4 to ground. In this case the resistance R_4 would be in series with the trolley circuit breaker, fuse and ground. Considering the E. M. F. consumed by the resistance R_4 and the high counter-electromotive force of the arc, it is evident that sufficient current would flow in the arc to destroy the controller and still not open the circuit breaker. This arc would continue until it formed a direct short circuit and opened the circuit breaker. This condition may be easily imagined by referring to Fig. 1, which is an elementary diagram of a standard controlling wiring, the reverser and lower drum contacts being omitted to simplify the figure. The controller handle is in position 5.

THE ARC.—To study the behavior of an arc during the interval of time that elapses for a

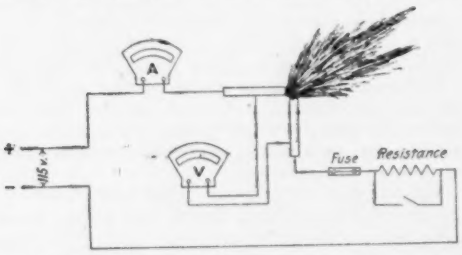


Fig. 2. Apparatus Showing Behavior of Heavy-Current Arc.

fuse in circuit to blow, the following experiment was performed by the writer. A hand-feed arc lamp was connected in series with a 100-ampere ammeter, a 50-ampere fuse, a regulating rheostat and the 115-volt service, as in Fig. 2. The rheostat was shunted by a switch so that it could be short circuited at will. An arc was sprung between the carbons and the rheostat adjusted until 15 amperes was flowing in the circuit. This was intended to represent in an elementary way an arc which had jumped to ground in a controller case. Upon closing the switch short-circuiting the rheostat a current of 100 amperes passed through the arc, the fuse blowing shortly after. During the interval that elapsed for the fuse to blow there was a vicious, roaring discharge between the two carbons, the discharge being about 12 ins. in length (maximum). The conclusion arrived at from this experiment was that if a circuit breaker were set high, or caught, and a ground were to occur there would be the possibility of the controller burning out before the fuse would blow.

That it takes time to blow a fuse is evidenced by the well-known curve Fig. 3, showing the time required for a fuse to blow, with varying strengths of current. The time of blowing varies inversely as the square of the current between fixed limits. The rapidity with which a fuse will blow depends upon the amount of heat developed per unit of time. This relation is expressed by the following formula, where the quantity of heat developed is expressed in gram-calories—

$$\text{Gram-Calories} = 0.24 I^2 Rt.$$

Where I=the current strength in amperes,
R=the resistance in ohms,
and t=the time in seconds.

Continuing the experiments it was decided to determine how long it would take for a 100-ampere arc to burn its way through a metallic plate equal in thickness to a controller casing. Such an arc was sprung between a carbon and a metallic plate, and observations taken indicated a time interval varying from ⅔ of a second to 1 second, before the arc burned its way through the plate.

These experiments tended to show that if a controller became grounded through an arc, and the circuit breaker failed to open the circuit; it would be quite possible for the controller to burn out before the fuse would melt. In the second place the circuit breaker and fuse could both be

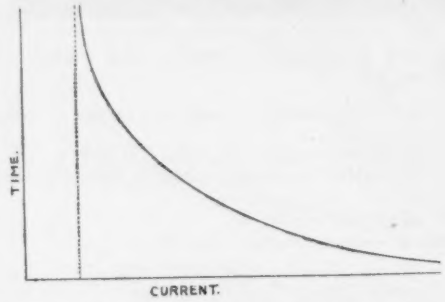


Fig. 3. Characteristic Curve of a Fuse.

in proper condition and the controller burn out providing an arc were to occur between the resistance fingers and the controller casing. This latter was the explanation of the severe instance previously mentioned. The circuit breaker and fuses were in good condition, the motors were in good order and the controller was almost new. The destruction of the controller occurred mainly in the vicinity of the resistance fingers; contact-fingers R_5 and R_6 were melted off completely, the insulation on several of the controller leads was baked and the controller lid was burned through in several places.

REMEDY.—It seems that so long as the main line current is interrupted in the controller case, just so long will controllers burn out. If controllers are frequently inspected, their insulation tested, and kept thoroughly clean, the danger from burning out is reduced to a minimum. Arcs, however, are bound to form when metallic dust, oil, and gritty matter accumulate, or when the blow-out magnet becomes short-circuited. The only way to eliminate the burning-out trouble is to use as a controller a modified form of the contactor system of control employed for heavy traction work, in which the heavy train line circuits are opened and closed by perpendicular break contactors located under the floor of the car and the arcs are extinguished by blow-out magnets. With this form of control a local current of small value passes through the master controller operated by the motorman, this current governing the operation of the main contactors, and being of such small magnitude as to cause no more trouble.

I wish to express my appreciation of assistance rendered me in the preparation of this article by Mr. Walter Tamlyn, of the Polytechnic Institute of Brooklyn.

THE NEW ARTESIAN WATER SUPPLY OF ITHACA, N. Y.

By F. L. Getman.*

The serious typhoid epidemic at Ithaca caused by the contamination of a surface water supply, supposedly by a force of Italians employed on a new storage dam being erected by the water company in Six Mile Creek, aroused the people to demand municipal ownership of the water works and an artesian water supply from a source which should be beyond the possibility of contamination.

Before the epidemic had reached its height a committee of one hundred citizens, which was later replaced by an able water board composed of the mayor and six citizens, one of whom was the late Prof. Robert Thurston, commenced prospecting in the lowlands of Cayuga Lake Valley for an underground supply, and engaged Mr. C. C. Vermeule as consulting engineer.

The City of Ithaca (see map Fig. 1) is located at the foot of Cayuga Lake and is distributed over the lowlands and both hillsides of the lake valley which rises abruptly to about 1,100 ft. elevation; while the lowlands, which extend to the south of the city two miles, are only a few feet above the lake level and often during heavy rains are completely submerged. From the lowlands the valley rises slowly to the south until at Spencer Summit, 12 miles distant, it reached an elevation of about 600 ft, above the lake level. This summit forms the southern limit of the artesian basin.

The geological formations in the valley of Cayuga Lake are of unusual interest. The valley itself is of glacial formation, being gouged deep into solid rock, then partially refilled with glacial detritus. A boring for salt wells in the vicinity encountered the rock which formed the bottom of the original valley at an elevation of 25 ft. below sea level and soundings in the lake revealed even greater depressions.

The lowest part of this great rock valley is occupied by Cayuga Lake, about 1½ miles wide and stretching from Ithaca to Auburn forty miles northward. The main portion of Ithaca is built upon flat lands reclaimed from the lake by a delta formation. These low delta lands extend about two miles south of the city and to the hills on the east and west. At the mouth of numerous gorges through which small creeks enter the valley occur gradual mounded elevations composed of rock scourings and deposits from these rapid streams formed into alluvial fans.

To the south of this low delta extends a morainic formation which reaches its maximum elevation 680 ft. above the lake, about twelve miles from the city. The gravels of these moraines are underlaid by rock and for at least four miles up the valley they are covered by clay and hardpan. Where they outcrop far south, the water percolates freely downward and then flows northward beneath the clay. As the strata dip downward more rapidly than the surface, the water-bearing sand and gravel is found over 280 ft. below the surface at the wells. The water finally discharges into Cayuga Lake far below its surface, and at a considerable distance north of Ithaca, as is evidenced by the existence of springs welling up into the lake.

The surface soil in the vicinity of the new artesian wells is of muck to a depth of about 6 ft. Underlying this is a clay to a depth of 50 ft. to 60 ft., under which in all wells an upper stratum of water-bearing sand and coarse gravel was encountered. It is from this upper pervious stratum that the many shallow wells driven in the city draw their supply. These gravels probably extend to the valley sides and as at the mouths of the creeks the covering clay is absent, the water from these streams is allowed to sink and follow the gravel into the earth.

It was Six Mile Creek, one of these polluted surface streams, which supplied the water caus-

*Resident Engineer, Ithaca, N. Y.

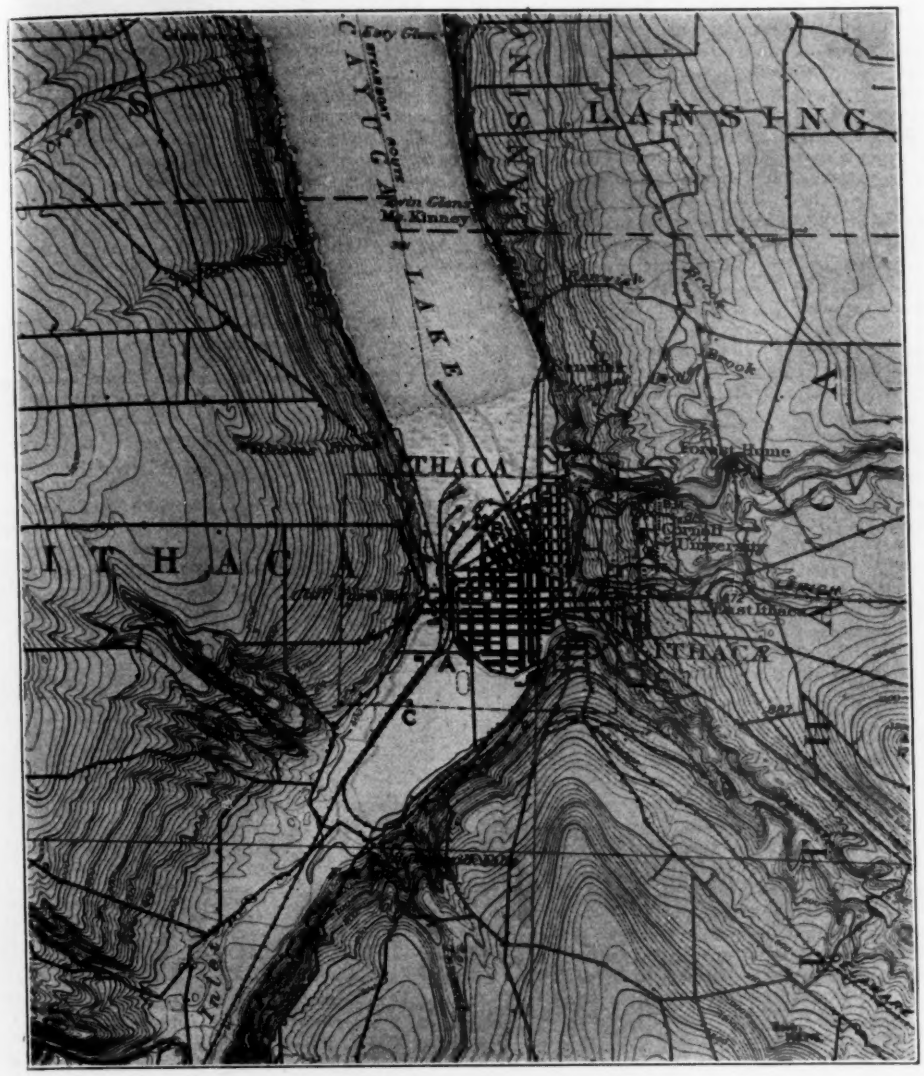


FIG. 1. MAP OF ITHACA, N. Y., AND VICINITY, SHOWING LOCATION OF TEST WELLS A B C AND OF TEMPORARY ARTESIAN WELLS AT A.

the epidemic and the fact that chemical and bacterial examinations of nearly all shallow wells in the city during the epidemic showed a general contamination of the waters makes this theory extremely plausible. Examinations of the materials in this stratum showed the sand to be well washed and the gravel rounded and water worn

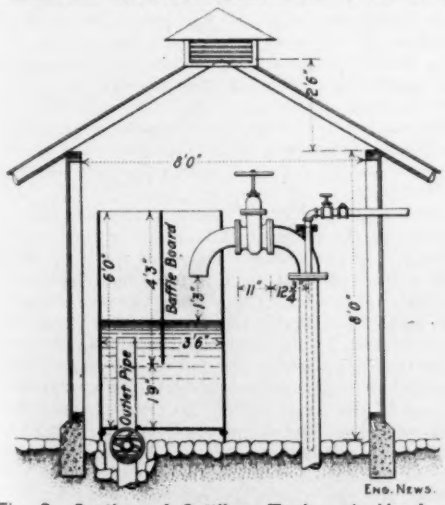


Fig. 2. Section of Settling Tanks at Head of Artesian Wells.

similar to the pebbles still being brought down by the creeks and found in the alluvial fans.

Seven different wells encountered logs at depths varying from 33 to 110 ft. One well penetrated two logs. These logs lay horizontally or nearly so, and varied from 1 to 2 ft. in thickness. The specimens examined were of pine and tamarack in a perfect state of preservation. In almost every case the logs were encountered in the gravel, usually lying at the upper or lower limit of the stratum. The frequency of their occurrence demonstrates that following the formation of the deep clays the surface was covered with vegetation and forests which were later depleted and buried by the gravel washed into the low valley by the torrential streams which entered its sides.

These upper water-bearing gravels are underlain by a stratum of firm blue clay varying in the different wells from 120 to about 180 ft. in thickness. The upper portion of this stratum was usually pure blue clay, but as it was penetrated deeper it varied in consistency, being intermixed with fine sand, sand and gravel and well rounded stones from 2 to 4 ins. in diameter, while in two wells the strata terminated in a blue clay hardpan which was very difficult to pierce.

Underlying this thick stratum of impervious clay the deep water-yielding gravels were encountered and in two cases where the wells were driven through these the rock valley bottom was found underlying them.

To insure an early completion of the work the development of this deep-seated water was confined to the low lands in the immediate vicinity of the city, thus avoiding consumption of time in constructing long pipe lines to connect with the mains already laid in the streets. These 6-in. wells were put down at the points A, B and C (Fig. 1). All three were sunk to water-bearing strata at depths varying from 230 to 300 ft. At A and C Pleistocene gravels were penetrated which yielded small amounts of water, while the well farther north at B struck into a stratum of sand too fine to supply water in the desired quantities.

After a thorough study of the geology of the various strata encountered, the direction of flow in the subterranean stream and the general character of the underground watershed it was decided to locate the well-sites near Clinton St. (marked A, Fig. 1) where the borings and an existing well indicated the location of the coarser gravels which are the better water-yielding.

The city of Ithaca has a population of about 15,000. Allowing the liberal per capita consumption of 100 gallons daily, 1,500,000 gallons daily would be required, which is approximately the present minimum consumption. It was decided to develop a supply of about 2,000,000 gallons for this temporary plant and later investigate the possibility of installing a permanent artesian gravity supply from the hills about twelve miles east of Ithaca where water was known to exist.

Thirteen 6-in. wells were drilled in the vicinity of Clinton St., and nine of them developed a natural flow in quantities varying from 27,000 to 348,000 gallons per day, making a total of somewhat over 1,000,000 gallons daily. In the other four, one reached bedrock without encountering a water bearing stratum. Three ended in wet quicksand too fine to be water-bearing. In one of these the quicksand when penetrated rushed up the pipe 150 ft. Each flowing well had a static pressure of about 18 lbs. per sq. in. at the surface of the ground, which indicates the high elevation of the source of the supply. The temperature of the water taken in August and December was 52° F. in each case, indicating the long underground journey of the water and that the source was well removed from danger of local contamination.

The general distribution and arrangement of the wells was governed by the peculiar variation of the water-bearing gravel. The coarsest material was found just northeast of the intersection of Clinton St. and the Lehigh Valley R. R., (marked A, Fig. 1) where the water-bearing stratum was composed of stones varying in size from those which could just pass up the 6-in. pipe to small gravel somewhat intermixed with black sand. The natural flow of the well soon washed out the sand. Under the above conditions the wells were grouped more closely at this point than they would have been had more time been available to extend the area and lay longer collecting pipes.

In several of the wells the gravels were intermixed with so large a proportion of very fine sand that the water was unable to penetrate except in small quantities until the sand was thoroughly washed out by a hydraulic bit and the gravel left deposited about the foot of the drive pipe to form a natural strainer, through which a flow could be established. This once done, the well often threw sand for weeks and thus enlarged the gravel strainer and consequently the flow. As the wells were put down with ordinary bits constant vigilance was necessary when approaching the lower limit of the clay, which was intermixed with sand, in order that the water-bearing strata should not be passed.

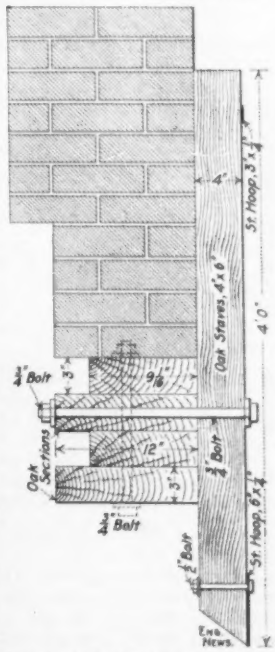
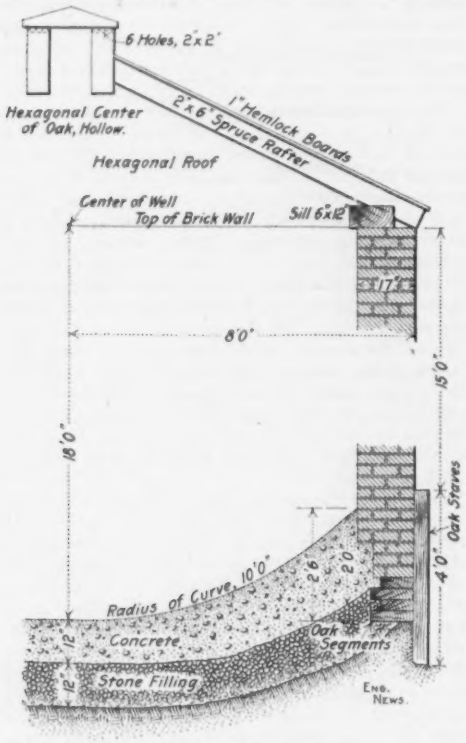


Fig. 3. Sinking Shoe for Pump Well, Ithaca Municipal Water-Works.

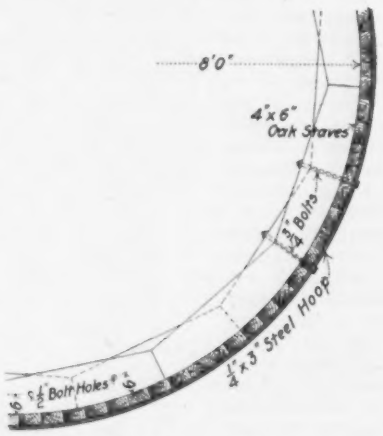
By the use of air lifts installed by the Ingersoll-Sergeant Co. the natural flow of about 1,000,000 gallons daily was increased to 1,800,000. In order that the pressure and quantity of compressed air, which was supplied to each well by a compressor

at the pump house, might not vary, all air pipes were placed in the wells at a uniform depth of 150 ft. below the surface and the air was regulated at each well head by setting an air-cock. Back of this a valve was placed on the air pipe allowing the air lift to be shut off without disturbing the regulation.

The well heads delivered the water into circular iron plate settling tanks (Fig. 2) 42 ins. in diameter and 6 ft. high, set on concrete foundations above the reach of spring floods. The tanks are divided through the center by a baffle plate which extends from the top to within 18 ins. of the bottom and the 6-in. draw-off pipes extend through and 3 ft. above the bottom, preventing any coarse



Half Vertical Section.



Quarter Foundation Plan.

Fig. 4. Details of Pump Well, Ithaca Water-Works.

sand or gravel or air from being carried into the collecting mains.

The collection system consists of 6, 8 and 12-in. pipe which delivers the water into a covered brick suction well at the pump station where it is allowed to deposit any fine sand, should it be present, before passing to the pumps.

The circular double ring brick suction well was sunk on a wooden shoe, Figs. 3 and 4. It is 16 ft. in diameter and about 20 ft. in depth, provided with an arched concrete bottom and covered by a conical tin roof with ventilating cupola. The well was sunk by excavating inside and allowing the edge of the shoe to penetrate the soil ahead of the brickwork. In the bottom of the suction well a small air ejector was placed by means of which any sand collected might be thrown into the overflow without drawing off or roiling the water.

On account of the marshy unstable character of the soil at the pump station site and the limited time, which did not allow the driving of many piles, only the stack and boiler foundations were piled. The building, pumps and other machinery were supported by a mattress laid on the surface of the marsh. This was formed by laying on the surface fine brush so that when compressed it had a thickness of about 4 ins. and extended 10 ft. in each direction outside of the area to be covered by the pump house. Poles from 6 to 9 ins. in diameter spaced 1 ft. apart were laid across the brush. On top of this mattress 6 ft. of large stones and gravel filling were placed and thoroughly rammed by hand and packed by teams passing over them. Upon this the concrete foundation for the walls and machinery were laid.

The pump house is 30 × 40 ft. in plan, fitted with two vertical 200-HP. Corliss boilers (to save time in setting and in floor space), one Berryman feed-water heater, two small duplex feed pumps, one Ingersoll-Sergeant straight line compressor, one Worthington and one Dean duplex compound pump, each with a capacity of 2,000,000 gallons daily.

The 12-in. force main was laid from the pump station up Clinton St. about one mile to the 12-in. city main which connects the city with a reservoir on South Hill. Cross connections were left for each intersecting street to improve the pressure in that part of the city where a large part of the head was previously lost by long lines of small pipe.

COST OF CONSTRUCTION.

The wells were of 6-in. heavy drive pipe, sunk by ordinary churn drill and sand pumps assisted by washing with a hydraulic bit, where fine sand was encountered to give free passage should water be present. Six of the wells were put down by a well-driving machine purchased and operated by the city at the average cost of $1.81 per lin. ft. of depth. This cost includes drive pipe, washing, developing, moving drills, new cables, machine repairs and over three weeks spent in fishing for a string of tools lost in one of the wells.

The above cost is itemized as follows:

	Per ft.
Drive pipe and machine work on same	$0.81
Fuel and oil	.22
Labor (driller, helper and firemen)	.70
New cables and repairs	.08
	$1.81

For the first 100 ft. of depth the cost of drilling and sinking the well, exclusive of pipe, ranged from 19 to 49 cts., the average being 37.1 ct. per ft. Adding to this 81 cts. for pipe makes a total of $1.18 per ft.

One well put down by a machine and crew hired by the city at $20 per day, cost $2.03 per ft., including pipe. The other wells were drilled by contract at $2.25 per ft., not including washing or developing the wells, this being done by the city workmen.

At the pump station the brush mattress, previously described, was laid at a cost of 27 cts. per sq. yd. The piles, which were 30 ft. long, cost 25 cts. per ft. driven.

The concrete in the foundations was made of a mixture of sand and gravel from a creek bed, which examined showed to be 41% voids, the gravel 33% voids, theoretically requiring 4.4 cu. ft. of cement per yard of concrete. Three sacks of cement to ten wheel-barrows of the gravel and sand were used, making about a 1: 2 2-3: 4 mixture, which gave a very satisfactory concrete. The concrete of which there was 163 cu. yds., was mixed by four men and rammed into place by another. These men were paid $1.75 per day of 9 hours. The cement cost $1.50 per barrel, being furnished by the Cayuga Lake Cement Co.

The itemized cost was:

	Per cu. yd.
Labor	$0.87½
Forms	1.16
Tools	.09
Cement	1.77
Sand and gravel	1.00
	$4.89

The suction well cost as follows:

Shoe	$100.81
Lumber, tools and material	168.40
Brick and mortar	188.20
Concrete bottom	35.00
Labor	824.69
Roof	27.30
Vitrified brick lining	251.79
	$1,596.19

The entire cost of developing and installing the artesian water supply, including one mile of in. force main, was about $55,000. The plant was intended to be temporary and was purchased second hand in the open market. Economy of operation was not considered, as it is expected that the plant will be replaced by a gravity supply from the hills. It furnishes a supply which is entirely wholesome and which, although high in mineral salts, does not form boiler scale.

Mr. C. C. Vermeule was the consulting engineer for the Ithaca Water Board, and the author was resident engineer for Mr. Vermeule.

AN AIR COMPRESSOR WITH MECHANICALLY CONTROLLED POPPET VALVES.

The modern tendency away from belting and gearing and toward direct driving of machinery wherever possible has led the Laidlaw-Dunn-Gordon Co., of Cincinnati, O., to the design of a new system of valves and gear for air compressors, which enables these machines to be run at the relatively high speeds involved by direct connection to prime movers without sacrifice of efficiency. This system, known as the Cincinnati valve gear, is exhibited in the illustration herewith. Fig. 1, a longitudinal section through a compressor cylinder, shows the arrangement of

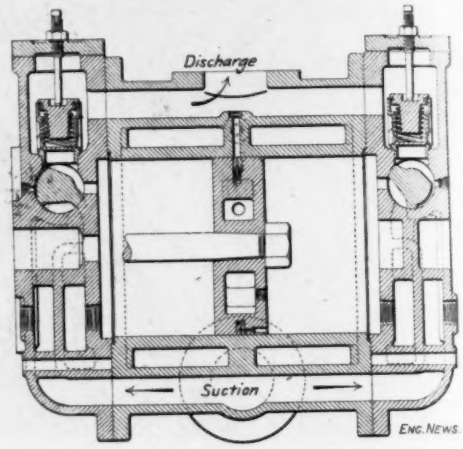


Fig. 1. Longitudinal Section Through Compressor Cylinder, Showing Combination of Rotary and Poppet-Valves.

the valves, and Fig. 2, a view of a complete compressor, shows the operating gear.

As may be seen in Fig. 1, each end of the cylinder has two valves, acting in combination. The one nearest the cylinder is a rotary valve, actuated directly by an eccentric rod attached to the valve arm. Above the rotary valve is a spring-closed poppet valve, which closes the passage leading to the discharge pipe. The poppet and the rotary valve act in conjunction to regulate the beginning and end of the discharge; the rotary valve alone opens and closes the suction. The combination of valves has the effect of giving a variable discharge opening, with fixed time of discharge closing and fixed time of suction opening and closing.

The arrows in Fig. 1 indicate the direction of motion of the parts at the instant of time represented, and the general course of the air. With the piston moving to the left, the right-hand rotary valve leaves the suction passage open to the right-hand end of the cylinder, but closes the suction just at the moment the stroke is completed; it continues to rotate anti-clockwise until, shortly after the beginning of the return stroke, it opens the cylinder to the space under the poppet. When the air pressure in the right-hand end of the cylinder reaches the delivery pressure, the poppet lifts and air is discharged. When the middle of the stroke is reached, however, the rotary valve reverses its motion and begins to cover the discharge port. This condition is that shown in Fig. 1 for the left-hand side. When the piston nears the end of the stroke the rotary valve closes the discharge port. The poppet valve can then seat itself gently, under the influence merely of its spring pressure. The discharge port being closed just before the end of the stroke, no back-

blowing of air from the delivery pipe can occur. Shortly after the beginning of the suction stroke the rotary valve opens the suction, then begins to reverse its motion, and finally, near the end of the stroke, again closes the suction.

The compressor of this type illustrated in Fig. 2 is a double-end two-stage compressor designed to work at 170 r. p. m. It will run direct-connected to a 150-HP. Crossley gas engine; the frame and general construction of the compressor were designed to harmonize with the engine and to make the unit specially compact. The crank shaft of the compressor is extended on one side and coupled to the engine shaft, carrying a flywheel between the adjacent compressor and engine bearings. The compressor has cylinders 21 and 12 ins. in diameter, with 12-in. stroke. It is to work against 100 lbs. pressure. The two cranks of the compressor are set at right angles.

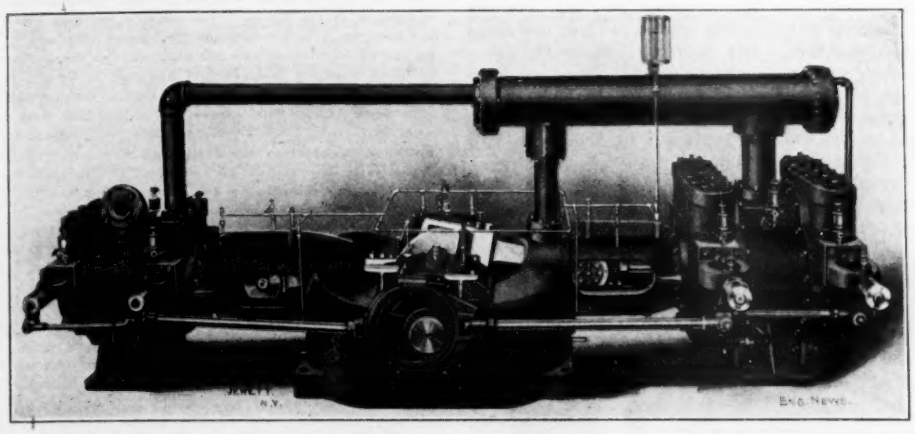


FIG. 2. VIEW OF DOUBLE AIR-COMPRESSOR WITH MECHANICALLY-CONTROLLED POPPET-VALVES.

Another machine of this type was built recently for direct connection to a 150-HP. motor, with armature mounted on the compressor shaft between the frames of the two sides. The dimensions of the compressor in this instance are 18 and 11 ins. by 24 ins., and the speed is 120 r. p. m.; the machine works against an air pressure of 100 lbs. per sq. in.

WORK OF THE LOCOMOTIVE TESTING PLANT AT THE ST. LOUIS EXHIBITION.

When the locomotive testing plant was installed by the Pennsylvania R. R. at the St. Louis Exhibition last year,* the committee in charge outlined a schedule providing for the testing of twelve locomotives, but a bulletin recently issued states that owing to difficulties and delays not within the control of those in charge of the work it was not possible to carry out the complete schedule. The delays were due largely to such incidental causes as hot bearings and flat spots on the supporting wheels, and also to the necessity for experimenting with oils to determine the best lubricant for use in the absorption brakes. The lubricant finally selected was composed of ⅞ valve oil and ⅛ castor oil. The more viscious oils gave the best results, as the energy absorbed by the oil increases with the viscosity, thus permitting a lower water pressure to be maintained on the absorption brakes. The water was taken from the city mains, and at times there were violent fluctuations in the pressure; these were transmitted to the absorption brakes, causing difficulties in handling the engines at the required speed. In some cases, this resulted in slipping the driving wheels, causing flat spots on the supporting wheels. At high speeds, the backward and forward motion of the locomotives caused a reversal of stress on the drawbar, but this was remedied later by placing all dash-pots between the dynamometer housing and the tail piece of the locomotive.

Considerable time was spent in making analyses of coal, and that finally adopted was furnished by the Berwind-White Coal Mining Co. It was of very good quality, but friable, and under a strong draft much of the fine material was drawn through the tubes. The heating value averaged over 14,000 B. T. U. per lb. of dry coal, and a proximate analysis showed fixed carbon, 75.85%; volatile combustible, 16.25%; ash, 7%; moisture, 0.9%. The sulphur, determined separately, was 0.9%.

It was originally intended to issue a bulletin at the conclusion of each test, but the unexpected delays made this impracticable. The results of the tests of one locomotive, however, are given in the bulletin above referred to, and the others will be published later in book form. The performance of each locomotive was considered under three divisions: 1, the boiler; 2, the engine; and, 3, the locomotive as a whole. With the separation of the engine and boiler performance it will be possible to make accurate comparisons and to predict the effects of interchanging the boilers and engines of different locomotives.

TESTS OF A CONSOLIDATION FREIGHT LOCOMOTIVE.—The bulletin above-mentioned gives the results of tests made on a Pennsylvania R. R. standard heavy consolidation (2-8-0) freight engine. Its maximum tractive effort is 39,773 lbs., calculated on the assumption that 80% of the boiler pressure is available as mean effective pressure at starting. The ratio of adhesion weight to this tractive effort is 1 to 4.35. The principal dimensions of the engine are as follows:

Driving wheels	56 ins.
Wheelbase, driving	16.55 ft.
Wheelbase, total	24.77 "
Weight on drivers	173,200 lbs.
Weight, total engine	194,200 "
Cylinders	22 × 28 ins.
Valve gear	Link motion and balanced slide valves.
Boiler, diameter, first ring	71 ins.
Boiler pressure	205 lbs.
Firebox, Belpaire	116 × 66 ins.
Firebox, depth at front, 66 ins.; at back	54 ins.
Tubes, No. 373; diameter, outside	2 ins.
Tubes, length, 164.5 ins.; fire area	6.09 sq. ft.
Heating surface, tubes (exterior area)	2,677.27 " "
" " total	2,843.67 " "
" " total, with int. area of tubes	2,482.26 " "
Grate area	49.21 " "
Exhaust nozzle, single; diameter	5.75 ins.
Ratio of total heat. surface to grate area	50.44
Ratio of fire area of tubes to grate area	0.124

There were 17 tests made, the shortest being for 130 minutes and the longest 210 minutes. In preparation for a test, the locomotive was gradually brought up to the desired conditions and then run for 10 or 15 minutes before observations were commenced. In the preliminary running, the coal and water were not weighed, but at the signal to start the test a box of weighed coal was dumped on the firing platform. The heights of water in the boiler and the feed-water tank were noted, and all coal and water used during the test was carefully weighed. At the conclusion, the water levels were brought to the heights noted at the start. From the numerous detailed tables of results for individual tests we have compiled the following table of results obtained at minimum, medium and maximum speeds. It is unfortunate that these must, for the present, stand simply as records of one engine. When the complete report of tests on all the engines is made public it will be possible to institute some comparisons as to the performance of different engines:

RESULTS OF TESTS OF CONSOLIDATION FREIGHT LOCOMOTIVE ON TESTING PLANT.

A. Performance of Engine.			
Revolutions per minute	40.33	92.74	160.50
Speed, miles per hour	6.70	15.40	26.66
Cut-off, per cent. of stroke	22.44	22.80	42.14
Mean effective pressure	85.76	66.33	50.23
Ind. HP.	365.70	650.0	851.70
Dry steam per Ind. HP.-hour	28.33	25.51	27.30
B. Performance of Boiler.			
Ave. boiler pressure, lbs.	200.4	197.6	201.8
Ave. temp. of feed water, Fahr.	73.9	63.7	73.5
Total coal per sq. ft. of grate, lbs.	57.2	129.4	184.9
Water, evap. per hour	10,828	17,195	25,860
Equiv. evap. (from and at 212°) lbs.	12,870	20,581	30,747
" " per sq. ft. of grate surface per hour, lbs	262	418	625
Equiv. evap. per sq. ft. of heat. sur. per hour, lbs.	5.18	8.29	12.39
Equiv. evap. per lb. of dry coal	11.53	9.85	7.39
" " per lb. of combustible.	12.42	10.61	8.00
Boiler HP.	373.0	596.5	891.3
" " per sq. ft. of grate surface	7.58	12.12	18.12
" " per sq. ft. of heat. surface	0.150	0.240	0.359
Combustible, fired per hour, lbs.	1,036	1,939	3,842
Rate of combustion, dry coal:			
Per sq. ft. of grate per hour	22.7	42.4	84.6
Per sq. ft. of heat. s. per hour.	0.45	0.842	1.677
B. T. U. per lb. of dry coal	14,109	14,144	14,651
Cinders and sparks per hour, lbs.	108	78.3	492.3
Draft, in ins. of water:			
In front of diaphragm	....	2.08	4.25
Back of diaphragm	1.05	1.63	3.62
In firebox	0.70	1.369	2.173
In ashpan	0.56	1.03	1.09
Temperature (F.) in firebox	1427	1662	1821
Temperature (F.) in smokebox	561	562	726
Efficiency of boiler	78.93	67.25	48.69
C. Performance of Locomotive.			
Drawbar pull, lbs.	15,706	12,587	9,118
Dynamometer, HP.	280.6	517.0	603.7
Dry coal per dyn. HP. per hr., lbs.	3.84	3.93	6.48
Dry steam per dyn. HP. per hr., lbs.	36.91	32.07	35.87
Machine friction, in HP.	85.1	133.0	248.0
" " in mean eff. press., lbs.	19.97	13.57	14.61
Machine friction, drawbar pull, lbs.	4764	3237	3485
" efficiency, per cent	76.74	76.94	75.78

The bulletin states that the temperature of the firebox increased at a much greater rate than that of the smokebox as the rate of combustion increased; in fact, the variation of the latter was comparatively small. The equivalent evaporation per lb. of dry coal ranged from 11.53 to 6.63 lbs., the heating value of the coal being practically uniform. The efficiency of the boiler dropped rapidly as the rate of evaporation increased, having the rather wide range from 78.93% at 12.42 lbs. per lb. of combustible to 45.37% at 7.11 lbs. The highest boiler horse-power developed was 891.3 HP.

The effects of speed and cut-off upon mean effective pressure are shown by the tables; for instance, at 80 revolutions per minute and cut-off of 20, 30 and 40%, the pressure was 68.12, 92.42 and 108.99 lbs., respectively; at a constant cut-off of 30%, but with speeds of 40, 80, 60 and 120 revolutions, the pressure was 106.34, 92.42, 76.75 and 57.09 lbs., respectively. The highest power developed by the engine was 1,036 I. HP., obtained at 30% cut-off and 120 revolutions per minute. The best performance of the engine was a steam consumption of 23.43 lbs. per I. HP.-hour, at 31½% cut-off and 120.12 revolutions per minute (about 20 miles per hour). With throttle full open, the differences in steam consumption per I. HP.-hour were small.

PERFORMANCE OF THE LOCOMOTIVE.—The performance of a locomotive taken as a unit is best measured in terms of drawbar pull or dynamometer horsepower, as these factors determine the usefulness of the machine for hauling cars. The maximum average recorded drawbar pull was 22,078 lbs. at a nominal speed of 80 revolutions per minute and a nominal cut-off of 37%. Higher drawbar pulls were not obtained because at slow speeds and long cut-offs there was constant danger of stalling the brakes and slipping the drivers owing to the fluctuations of the pressure of the water used for controlling the brakes.

The maximum dynamometer horse-power was 848.6 HP., which was obtained at a nominal speed of 120 revolutions per minute and a nominal cut-off of 35%. The general tendency is for the coal per dynamometer HP.-hour to increase as the speed increases. The minimum coal rate obtained was 3.54 lbs. and the maximum rate 6.48 lbs. per HP.-hour. The lowest steam consumption was 26.14 lbs. per dynamometer HP.-hour, which was obtained at a nominal speed of 80 revolutions per minute and a nominal cut-off of 37%.

The friction of the mechanism of the locomotive is given in terms of horse-power, mean effective pressure and drawbar pull respectively. At a given speed, the general law governing the variation of these factors is not apparent. In fact, the machine friction appears to be a constant for any given speed, and for this reason the average value of these items has been worked out for each speed. The average value of the frictional HP. for nominal speeds of 40, 80, 120 and 160 revolutions per minute was 83.1, 132.5, 187.2 and 224.2 HP., respectively. The average value of the frictional mean effective

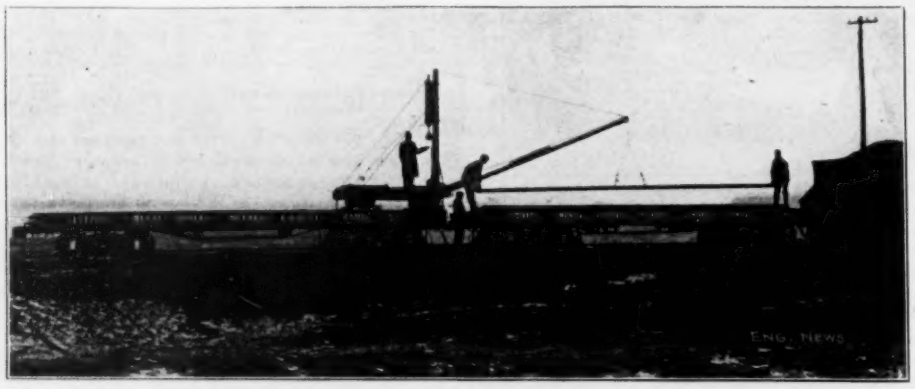
*Engineering News, May 19, 1904.

pressure was 19.47, 15.06, 14.72 and 13.29 lbs., respectively; and the average frictional drawbar pull at the same speeds was 4,644, 3,591, 3,511 and 3,171 lbs., respectively. These figures disclose the fact that the frictional mean effective pressure and frictional drawbar pull decrease as the speed increases, which is consistent with the general laws of friction.

The machine efficiency ranged from 72.89% to 84.82%. In view of the fact that the frictional HP., frictional mean effective pressure and frictional drawbar pull are each practically constant for a given speed, it follows that the machine efficiency at a given speed should be expected to increase as the cut-off increases. The results are, in general, consistent with this assumption. For example, at a nominal speed of 40 revolutions per minute and a nominal cut-off of 20%, the machine efficiency was 76.74%. At the same speed, but with a nominal cut-off of 30%, the machine efficiency was 82.18%.

A RAIL LOADING AND UNLOADING MACHINE.

The loading of old rails, ties, etc., from the track onto cars for removal is work which, when done by hand, requires a large crew of men, and is both slow and expensive. The raising of heavy rails and throwing them upon the cars cannot be carried on continuously with any degree of rapidity, and rails thus handled are liable to be kinked and otherwise injured. The accompanying cut represents a machine which was designed specially for this work, and which is being used by a number of railways for loading and unloading rails and other similar work. It consists of a crane or derrick operated by a pneumatic cylinder on the mast and attached to a car which travels along the train (gondolas or flat cars). The hoist is operated by compressed air, furnished by the air-brake pump on the engine, the train brakes being cut out and the air taken by the machine direct from the main air-pump reservoir. By the use of a three-way cock on the engine the engine brakes can still be operated, so that the train is under control at all times. The hoist has a clear lift of 14 ft., and a maximum reach of 19 ft. from the center of the track.



RAIL-HANDLING MACHINE; MINNEAPOLIS, ST. PAUL & SAULT STE. MARIE RY.
United Supply & Mfg. Co., Chicago; Builders.

The machine can be operated successfully on flat cars as well as gondola cars with drop ends or permanent ends, and can easily be shifted from car to car as required. It is equipped with two sets of wheels: there is one set of flat-faced wheels for use in moving along flat cars and through gondolas having drop ends; the others are double-flanged wheels for running along the sides of gondolas having fixed ends, and these latter wheels are on telescopic axles so that they can be instantly adjusted to any width of car, or to run along the sides of cars that are bulged in the center. The machine can be easily turned around on a flat car, so that it can be operated from either end of the car. It is secured to the car by chains with hooks, which fasten under the car sills and are tightened quickly and securely by turnbuckles. It is stated that it can be set up ready for work in 30 minutes after being dismantled, and the mast can be lowered or raised in four to five minutes. It can be shifted from one car to another of practically the same height and be secured ready for use in about five minutes; or it can be transferred from a flat car to a gondola (or vice versa) in about eight minutes.

The full crew to operate this machine rapidly consists of five men, as compared with 20 to 26 men for loading rails by hand. This gives a great saving over working with hand labor, especially when the work train has to run long distances or to spend much time on the siding to allow trains to pass. It also eliminates the liability of accidents to the men, as well as the liability to kink or damage the rails. It is stated that an experienced crew can load or unload rails on 1¾ to 2 miles of track per day, with ordinary delays, and distribute the new rail near the track in the best position for laying, with the head uppermost, as well as loading the old rails in tiers ready for shipment. The best results are obtained while the train is moving at a speed of about ¾-mile an hour, and 100 rails per hour is given as a fair average for loading or unloading with a trained crew and ordinary delays. The machine will operate successfully on curves, and in loading rails that have rolled down embankments, also in loading or unloading rails from stock cars. This machine is built by the United Supply & Mfg. Co., 1535 Railway Exchange Building, Chicago.

Reports from numerous railways show very satisfactory results. In one case, 100-lb. 33-ft. rails were transferred from high-side gondolas to flat cars at the average rate of 1⅓ rails per minute. Reports of two other cases are noted below:

Unloaded 73 rails (85-lb. 33-ft.) from high-side gondolas with permanent ends in 90 minutes, making two lifts to each piece (which now is not necessary); this is as fast as 25 men can do it by hand, and rails are often bent when thrown from top of car.

Unloading 80-lb. and 90-lb. rails from low-side ore cars: 1st car, 42 pieces in 60 minutes; 2d car, 46 pieces in 45 minutes; 3d car, 18 pieces in 18 minutes; total, 106 pieces in 123 minutes; average, 1.15 pieces per minute. Next 9 cars averaged 1 piece per minute. Crew of 6 men; 3 on car, 2 on ground and 1 at air hoist. Regular crew for doing this work by hand, 28 men; most ever handled, 323 rails in one day, and 220 pieces is daily average. Last car, 106 pieces in 106 minutes, and bottom tier of rails were frozen to the dirt and gravel in bottom of car. Loaded 27 pieces in 20 minutes, and part of these rails were frozen to the ground and had to be broken loose. Crew of 5 men; 2 on car, 2 on ground and 1 at air hoist.

The Buffalo, Rochester & Pittsburg Ry. has two of these rail-handling machines, and we are indebted to Mr. J. M. Floesch, Chief Engineer, for particulars of their service. With one machine, a crew has unloaded an average of 320 rails per day, equal to one mile of track. And they have picked up an average of 230 of the same kind of rails, or 0.7 mile of track, in 10 working hours. The crew for handling rails consists of one locomotive and train crew, six laborers and one foreman. The rails are 90 lbs. per yd., 33 ft. long, and were unloaded from high-side gondola cars. The rails that were picked up were loaded on flat cars and low-side gondolas.

We find the average cost per ton of unloading rails, including all train service, 21.4 cts. per ton. The cost of unloading by hand, including labor and train service, was 65 cts. per ton. Loading rails by machine, average cost, 30.2 cts. per ton, including all labor and train service; and by hand, 65 cts. per ton. We use the machine for handling frogs, switches, old ties and any other track material when we have a locomotive attached to our work train. The cost of handling rail with this machine, of course, depends upon the conditions surrounding the work. The above figures include the total cost of crew and laborers regardless of delays, in ten hours working time. Where traffic is very heavy the cost will probably vary somewhat from these figures, although the work from which the above record was taken was done on track on which there was very heavy traffic and the machine was not actually busy more than seven-tenths of the time. In unloading rail for storage, where the engine could stand on one track and there were no delays, we were able to unload rails from cars as low as 11 cts. per ton. In using the word ton, we mean gross ton.

From Mr. W. B. Causey, Engineer of Maintenance of Way of the Chicago & Alton Ry., we also have a report as to the use of the rail-handling machine, as follows:

The number of miles covered per day depends upon the number of trains the work train has to contend with. On our Western Division, between Roodhouse and Kansas City, we can average about two miles per day, or about 220 tons of 70-lb. steel. A foreman and five men is considered an economical crew, although the machine can be handled with fewer men. Our experience so far has only been with 70-lb. rail. We know no reason why the machine would not act just as efficiently with 80-lb. or 90-lb. rails.

The rails are loaded on flat cars, as the machine we have will not permit the use of any other kind of cars, unless we desire to load only one car at a time. In that event the machine can be loaded on flat car and rails can be loaded in gondola, but it would be necessary to switch out each car as soon as loaded before another car could be loaded. The cost of loading rails by hand is about 9 cts. per ton. Cost of loading rails by machine about 4½ cts. per ton, or half the cost of loading them by hand. These figures include wages of loading gang only. The cost of train service would be the same for both methods of loading. We have never used the machine for any other purpose than for loading old rails on cars.

The Illinois Central R. R. has a machine of a similar character manufactured by the American Car & Foundry Co., and from Mr. F. R. Safford, Assistant Chief Engineer, we have some particulars of the results obtained. The machine can load rails along 10,000 to 12,000 ft. of track per day, and has loaded (by actual count) 20,286 ft. of 60-lb. rail in 6 hours 47 minutes, working time. The crew is from seven to nine men, depending on conditions, and the rails handled weigh 60, 70 and 75 lbs. per yard. The rails are loaded on both flat cars and gondolas. The machine works best with flat cars, as the air hoist will not raise them quite high enough to load on gondolas to advantage; it can, however, be remodeled to allow of this being done. In a fair test it has loaded 75-lb. rails at a cost of 14½ cts. per ton, and 60-lb. rails at 15½ cts. per ton. The cost by hand under similar circumstances, by actual experiment, has been 25 cts. per ton for 75-lb. rail and 28 cts. for 60-lb. rail. The machine has also been used for unloading rails and frogs. It can be used for handling any material on or off cars where the air connection is available.

THE MASSACHUSETTS HIGHWAY COMMISSION had built 550 miles of roads at the close of 1904 and petitions for nearly 1,200 miles more had been received. The expenditure on repairs during the year 1904 was $52,000, or about $100 per mile of road. Nine contracts for maintenance are now in operation, covering 63 miles of road. The commission has 17 steam rollers, which averaged 87.4 days work each during the year; the cost of maintenance was $1,880, or $1.26 per roller per day worked. Three of the rollers, however, are about to receive thorough overhauling and repairs at a cost of $2,100.

There has been no failure of any V-shaped drains since the building of the first one by the commission three years ago. Of these drains the commission says:

They are apparently as effective as the telfording foundation and side drains combined, and cost much less to build.

On a heavy cut through clay washouts that filled the gutters with clay were frequent and expensive. Two years ago the commission experimented by covering the slope of the cut with a mattress of willow logs and limbs.

The willow shoots have got a good start over the entire surface of the slope and the washing is stopped.

The commission has planted about 4,000 trees at an average cost of $1.14 per tree, and advises further work of the same kind. Exclusive of engineering, the cost per mile of road for the contracts completed during 1904 was $5,750. Gravel and macadam roads are included in this average, and the reader will find it necessary to analyze the table with some care in order to find out what each class of road has cost.

ENGINEERING NEWS

A Journal of Civil, Mechanical, Mining and Electrical Engineering.

Entered at the New York Post-Office as Second-Class Matter.
Published every Thursday
at St. Paul Building, 220 Broadway, New York, by
THE ENGINEERING NEWS PUBLISHING CO.

PUBLICATION OFFICE, 220 BROADWAY, NEW YORK.
CHICAGO OFFICE, 1636 MONADNOCK BLOCK.
BOSTON OFFICE, 170 SUMMER ST.
ATLANTA OFFICE, AUSTELL BUILDING.

FOREIGN AGENTS.
RUDOLF MOSSE, BERLIN and HAMBURG, GERMANY.
JOHN F. JONES & CIE, 31 Rue de Faubourg Montmartre, PARIS.

SUBSCRIPTION RATES: United States, Canada and Mexico, One Year, $5.00; 6 months, $2.50; 10 weeks, $1.00. To all other countries in the Postal Union: Regular Edition, One Year, $9.00; Thin Paper Edition, One Year, $5.00 (21 shillings). SINGLE COPIES, 15c.
In requesting change of mailing address, state BOTH old and new address; notice of change should reach us by Tuesday to be effective for the issue of the current week. The number on the address label of each paper indicates when subscription expires, the last figure indicating the year and the one or two preceding figures the week of that year; for instance, the number 325 means that subscription is paid to the 32d week (that is the issue of Aug. 10) of the year 1905; the change of these figures is the only receipt, unless one is sent by special request.
ADVERTISING RATES will be furnished upon application. "Want" and "For Sale" notices (especial rates) see pages 26-27. The pages for new "Want" "Proposal" and "For Sale" advertisements are held open until Wednesday noon.

CLASSIFIED ADVERTISEMENTS for Engineering News may be left at the office of the Allen Advertising Agency, 617 Sixth Ave., near 36th St., or at any office in New York City of the American District Telegraph Co. Copies of "Engineering News" may be purchased at Allen Advertising Agency. The advertisements may be keyed so as to have answers addressed to any offices of the above-mentioned companies. Out of town orders for advertisements or copies of the paper must be mailed to the head office, 220 Broadway, New York.

WHEN WE NOTIFY you that your subscription will expire please to send your renewal at once, in order not to miss a number, using the special blank enclosed for that purpose. New subscriptions which are received by us on, or before, Tuesday of any week will begin with the current issue. If they are received after that day they will begin one week later. We cannot enter subscriptions to begin with back numbers. One week's notice is necessary before a change of address can be made.

Whatever opinion engineers may hold concerning the discharge of one Panama Canal Commission and the appointment of a new Commission, there must be universal agreement that the creation by the President of a special Board of Engineers to fix upon the general plan for the canal and report its conclusions to Congress is exactly the right thing to do.

As matters now stand, Congress, as representing the nation, undertook the canal work with the understanding that it was to be built with locks, was to cost a certain amount, and would require a certain number of years for completion. The Commission whose existence has just terminated has been collecting information for a year past to furnish ground for fair judgment as to what type of canal should be built, and two of its members went on record in a published report a few weeks ago as advocating a sea level canal. But the whole Commission never acted on this report, and Congress ought to have the advice of more than any one or two or three engineers before deciding so momentous a question as that of the type of canal to be constructed at Panama.

As matters stand at present, there has been some prospect that the nation would be committed to a sea-level canal at Panama, because it was favored by a majority of the newspaper editors, and was more popular with the public than a lock canal! Decidedly this is a poor basis on which to settle such a great national question. Perhaps a sea-level canal *is* the scheme to adopt; yet there is much to be said in favor of the lock canal, and for a valuable opinion as to the relative merits of the two the public must look to the engineering profession, as represented by its ablest members.

According to the published statements, the Commission will be made up of nine members, three of whom are to be engineers appointed by the Governments of Great Britain, France and Germany. This also seems to us a detail deserving hearty approval. While the United States has full responsibility for the design and construction of this great international waterway, and two-thirds of the Commission will be American engineers, recognition of the engineers of the three other great maritime nations is not only a happy bit of international courtesy, but can but add weight to the conclusions which the Commission may reach.

The engineers of the three countries named have far more experience in canal construction and operation than any American engineers; and it will be no small thing to have on the Commission engineers familiar with the results of experience on the Manchester Canal, the Kiel Canal, the Suez Canal or the canals at Corinth and Amsterdam.

Since the above note was in type, we have received a copy of the first report of the Chief Engineer of the Panama Canal Commission, Mr. John F. Wallace, and it is presented to our readers in full in this issue. It was evidently upon the strength of the facts summarized in this report that Messrs. Parsons and Burr, of the old Commission, based their recommendation for a sea-level canal, as printed in our issue of March 2, last.

With Mr. Wallace's report before them, the engineering profession generally will be able for the first time to form some intelligent opinion as to the comparative merits of the canal with locks and the sea-level canal. We say *some* opinion, for it is manifest that many matters that bear upon that question are not touched upon in the report. For example: a sea-level canal will be for a great part of its length far below the level of the adjacent country, and will have to be protected from the floods of adjacent streams, which would otherwise be continually filling it with silt. The floods from the upper Chagres will be taken care of by the storage reservoir created by a dam at Gamboa; but the watershed of the Chagres between Gamboa and Bohio has an area of 250 square miles, and the flood outflow from this whole area must be kept out of the canal prism, if a sea-level plan is adopted. This will necessitate, it would seem, a large expenditure for the construction of river diversion channels between Gamboa and Bohio; and it would be interesting to know what provision has been made for these in the comparative estimates.

Again it is at least an open question how much weight should be given to the argument that a sea-level canal is preferable because it will have greater traffic capacity and will involve less delay to shipping. The Isthmian Canal Commission of 1900 made pretty careful estimates of what volume of traffic might be expected to seek a canal at Panama, and their results showed that not for many years to come is any traffic likely to go there beyond the capacity of a lock canal to easily handle. It needs only a little study of the results actually accomplished with the single Poe lock at Sault Ste. Marie, operating during only a portion of the year, to make clear that a double lock system, handling vessels of ocean-going size, has a traffic capacity in excess of anything likely to be required at Panama for a long time. Again, the delay to shipping by passing through locks, is a very trifling matter in such long voyages as those which will be pursued via the Panama canal.

We do not say, of course, that these things should be given *no* weight in considering the relative merits of the two plans; but that their importance should not be exaggerated.

On the other hand, an advantage of the sea-level canal of which comparatively little notice has been taken is the saving that will be made in the annual charges for maintenance and for operation if locks are dispensed with. The Isthmian Canal Commission of 1901 estimated the annual cost of maintenance and operation of the Panama Canal with locks at $2,000,000. It is entirely probable that a considerable part of this sum might be saved if the locks were eliminated from the project. This saving would partially offset the interest on the excess of cost of a sea-level canal over a lock canal. Regarding this interest, it will be apparent that entirely different standards will prevail in fixing its rate from those which would be adopted in case a private corporation were building the canal for profit. The question at Panama is: What capital can the Government afford to invest to avoid a certain annual expense for operation and repairs? In solving this problem one should assume, not the interest rate that may prevail at the present time, nor even that at which the Panama bonds will probably be marketed; but the rate which capital will probably command for the highest class of investments during the next half century. Bearing in mind the rapid increase in accumulated wealth and the steady fall in interest rates the world over during the past half century; it seems safe to say that the Government might invest capital in such a work as that at Panama if the saving in annual expense by such an investment will yield 1½% interest on the principal. In other words, if the elimination of the locks would reduce the annual expense account by, say, $500,000, that would offset $33,000,000 of the added cost of a sea-level canal.

The municipal ownership and operation of public utilities is a fruitful subject for discussion in England as well as in this country at the present time; but while here municipal ownership is for the most part confined to works for water supply, in England a large proportion of the gas and electric lighting plants and the street railways are owned and operated by cities.

Of course, a large and influential party, in England as here, opposes municipal ownership at every turn. While to some extent this opposition represents the honest opinion of intelligent men, its real strength is derived from the corporations who find their profit in the control of these public franchises. These corporations are wealthy and influential enough to strongly influence the public press. Some years ago these opponents of municipal ownership hit upon the term "municipal trading," to designate the policy which they oppose, and since then the English journals have been filled with articles in condemnation of "municipal trading." Recently the term has been transplanted to this country, and American readers have been surfeited with tales of how English cities and towns have plunged themselves head over ears in debt by their "municipal trading" activities.

We are led to refer to this matter of "municipal trading" because there has just come under our notice the results of "municipal trading" in the gas industry in a small English town. In the United States is has come to be the rule that the gas business is a matter for private corporations alone to control. An illustration of the results of this policy has been presented to the public recently in the investigation of the New York city gas companies. A more damning revelation of the exploiting of a great municipality for the enrichment of a ring of promoters and stock-waterers it would be difficult to imagine. The price of gas in New York City is still maintained at $1 per M. cu. ft., in order to pay dividends on many millions of dollars of watered stocks.

In contrast with the results of "frenzied finance" in operating the New York gas system, we wish to place the results of "municipal ownership," or if you please, "municipal trading," in the little English town of Cleckheaton. Our information is taken from a paper read before the Association of Municipal and County Engineers, which held its annual meeting at Cleckheaton last month. We reprint the few paragraphs of the paper of immediate interest as follows:

> The purchase of the gas works was completed in 1870 from the Cleckheaton Gas Co., at a cost of £53,000, the make of gas at that time being about 30,000,000 cu. ft. per annum. Since the date of purchase, considerable extensions and alterations have been made to the works and plant, to meet the growing demands of the district, as at the close of last year the make of gas was 105,000,000 cu. ft. These alterations and additions cost about £12,000, but owing to the rapid developments which have taken place in the use of gas for tempering wire and other purposes, the profits of the department have been such as to enable the Gas Committee to pay off a large amount of the original capital; and instead of that item appearing on the yearly balance sheet at £53,000, it now only stands at £29,100, although the price of gas has been lowered from 4s. 6d. ($1.08) per thousand to 2s. 8d. (56 cts.), with discounts ranging from 10% to 15%.
>
> Cleckheaton ward is lighted by about 350 public gas lights and three electric arc lights. The cost of public lighting in gas alone is about £600, but no charge is made upon the ratepayers. The illuminating power required by the Act is 14-candle, but 17½-candle gas is supplied.
>
> The number of consumers is 3,000; the number of slot meters 1,100; the number of gas stoves and cookers 250.

Bear in mind that these figures are not put forward as any municipal ownership propaganda; nor are they presented as anything unusual or remarkable. They are simply a description of the

local public works of the town, presented to a professional society holding its meeting there.

If "municipal trading" can show such results as these, the public is pretty certain to favor it, no matter what bad names it may be called.

SAFE LIMITS OF WORKING LOAD FOR WHEEL PRESSURES.

What is the safe limit of surface pressure of a wheel rolling on a rail, or of a cylinder rolling on a plane surface? As some of our readers may remember, in our issue of Nov. 19, 1903, we discussed this subject in connection with the formula proposed by Mr. F. J. E. Spring, Consulting Engineer of the Indian Government Railways. This formula, deduced from current practice in loads of locomotive driving wheels and large capacity freight cars is as follows:

Safe load = 200 × diameter of wheel in inches × width of rail head on which wheel bears in inches.

In discussing this subject in the issue above referred to, we cited one particular heavy freight car in which the load per wheel is so high that the number 200 in the above formula is raised to 320; but we expressed doubts as to whether such high unit loads did not go beyond the limit of what the surface of the rail could stand without undue wear. It is doubtless the rail surface that fixes the limit and not the wheel, for either chilled cast iron or tire steel would doubtless stand a much higher unit pressure than rail steel before reaching the elastic limit.

It may be of interest to compare this rule with the common rules for proportioning the rollers under the expansion ends of bridges. The rule in "Cooper's Specifications" is that the pressure per lineal inch of roller shall not exceed 300 times the diameter of the roller in inches. The American Bridge Co. specifications require rollers to be at least 4 ins. in diameter and to have a maximum load per lineal inch of 1,200 × √ diameter. By this rule the load per inch of diameter per lineal inch would be 600 lbs. for a 4-in. roller, and 400 lbs. for a 9-in. roller. If this rule holds true for larger diameters, the safe limit of load for a 33-in. car wheel per inch of rail breadth would be about 210 lbs., × the diameter, which agrees well with Mr. Spring's rule quoted above; and the safe load of a 64-in. locomotive driver would be 150 lbs., × the diameter, or a total load on such a wheel, on a 2-in. rail head, of about 19,000 lbs.

It will be seen that this latter rule is in agreement with the position taken in the editorial in our issue of Nov. 19, 1903, in favor of permitting larger unit stresses per inch of diameter and per lineal inch of bearing, on small cylinders than on large.

In making further search for examples of high unit pressures on cylinders rolling on surfaces, our attention has been called to some tests recently made on Hyatt roller bearings by Prof. Arthur L. Williston, M. E., of Brooklyn, N. Y.*

It is, we believe, generally supposed by mechanical engineers that roller bearings are best adapted to comparatively light loads, and that where very heavy unit pressures are to be sustained, an ordinary bearing well lubricated is the most reliable.

In the tests above referred to, however, roller bearings were run at pressures far above what is practicable with ordinary bearings. The loads were distributed over four bearings, each 4 ins. long, and the shaft used was 1.496 ins. in diameter.. The following table shows the speeds and the coefficient of friction at the various loads:

185 R. P. M.		215 R. P. M.	
Total loads, lbs.	Coefficient of friction.	Total loads, lbs.	Coefficient of friction.
4,000	.0139	3,600	.0131
7,300	.0131	10,800	.0094
12,400	.0106	15,200	.0091
17,124	.0089	18,200	.0088
19,700	.0086	21,900	.0078
		23,500	.0076
Average	.0110		.0093
HP. (per 1,000 lbs.) per box.	.0379		.0374

A little computation will show that at the lower speeds a load was reached as high as 800 lbs. per square inch of projected area, and nearly 1,000 lbs. at the higher speed. These are figures much beyond the capacity of ordinary bearings. Prof. Williston states that at unit pressures of 250 lbs. per sq. in. for cast-iron bearings and 145 lbs. for the bronze bearings, there was difficulty in keeping the boxes from seizing the shaft.

*The tests are fully described in a published bulletin dated Jan. 3, 1905, which may be obtained by addressing the Hyatt Roller Bearing Co., Harrison, N. J.

Now let us see how the pressures on the rollers in the tests above reported compare with the figures for bridge rollers and railway wheels quoted above. Of course there is a little doubt in a roller bearing as to what part of the load is concentrated on a single roller. In the case reported in the table above ⅞-in. rollers were used with a 1½-in. shaft, and it seems a reasonable assumption that the maximum pressure per roller was equal to half the pressure on the shaft. As the pressure per lineal inch of shaft at heaviest load was 1,460 lbs., the maximum pressure per lineal inch of roller would be 730 lbs., and since the rollers are ⅞-in. diameter, the unit pressure per inch of roller diameter would be 830 lbs.

Prof. Williston's report states that even this excessively high loading did not injure the shaft, "the tendency of the rollers, especially at high pressure, seemed to burnish the shaft rather than score it"—to quote from his report.

In comparing these figures for roller bearings with those above for bridge rollers and car wheels, it must be borne in mind that the Hyatt rollers are not solid cylinders, but hollow. Under heavy pressure these rollers undoubtedly become slightly elliptical instead of circular in cross-section, and thus tend to distribute the load over a larger area of surface than a solid roller would. On the other hand, in a roller bearing the rolls travel on the convex surface of the axle instead of on a plane surface, and this would tend to greater concentration of the loads at the line of contact.

Before leaving the subject of roller bearings, we may note that the Hyatt company in their published rules for designing roller bearings advise that for trucks and cars on industrial railways, the journal pressures should not exceed 500 lbs. per sq. in. of projected area. For traveling cranes, trolleys, etc., where speeds are very slow, however, the load may run up to 1,000 lbs. per sq. in, of projected area, or even higher.

Next let us turn to a quite different field. We have considered so far the limits of surface pressure of iron or steel cylinders or wheels rolling on iron or steel surfaces. Let us now inquire how the same rule will apply to wagon wheels rolling on ordinary roads or on paved streets, and what unit pressures we shall obtain.

Take first the ordinary two-horse farm wagon, designed to carry a load of about a ton and used nearly always on dirt roads or on fields. Adding the weight of the empty vehicle to the load, we have a total weight per wheel of about 850 lbs. If the front wheels are 40 ins. in diameter and have 3-in. tires, the load per inch of wheel diameter and per inch of tire width is 7 lbs.

Let us turn next to present day traction engine practice. The Best Mfg. Co., of San Leandro, Cal., manufacture a traction engine weighing 16 tons complete, of which about 12 tons is carried by the two driving wheels. These are 8 ft. in diameter, with tires 24 ins. wide. Hence with a load per wheel of 12,000 lbs. the load per inch of diameter per inch of width will be 12,000 ÷ (24 × 96) = 5½ lbs.

The same company manufacture a freight carrying wagon with a capacity of 16 tons and a dead weight of 4½ tons, or a total load per wheel of 10,250 lbs. The wheels are 58 ins. diameter, with 10-in. wide tires; hence the load per inch of wheel diameter per inch of tire width is nearly 18 lbs. These engines and wagons are designed for use on ordinary dirt roads, in Western mining camps, lumber operations, etc.

Take next a heavy freight truck, such as is used in the larger cities on granite block, asphalt or other permanent paving. Such a vehicle drawn by two or three heavy draft horses may carry 6,000 to 9,000 lbs., and may weigh 4,000 to 5,000 lbs. Assume one weighing loaded 12,000 lbs., of which 7,000 lbs. are carried on the rear axle, or 3,500 lbs. for each rear wheel. If these wheels are 50 ins. in diameter and have 3½-in. tires, the load per inch of tire width per inch of wheel diameter will be 20 lbs., or three times as high a unit pressure as for the farm wagon, and one-tenth as great as the safe load for a chilled wheel rolling on a steel rail.

For a final example, let us examine the new English rules for motor vehicles, which aim to so limit the weight of such vehicles as to avoid undue damage to the public roads. We have reprinted the substance of these rules elsewhere in this issue. It will be seen that the rules are so complicated that a little study is necessary to find just what is the allowable limits of wheel pressure. Taking a vehicle with the maximum axle weight allowable, 8 tons, the maximum load per wheel will be one-half of this, or 8,960 lbs. Assume next that this wheel is 3 ft. or 36 ins. in diameter. Then by the regulations its width of tire must be as many half inches as the quotient of its registered axle weight divided by 7½ hundred weights. Since 8 tons = 160 cwt., the width of the wheel will be $\frac{160}{7.5}$ half inches, which equals 10.6 ins.

A load of 8,960 lbs. carried on a wheel 36 ins. diameter with 10.6-in. tire is a load of 26 lbs. per inch of wheel diameter and inch of tire width. This will be seen to be quite close to the figure which we obtained above for heavy horse-drawn trucks on city pavements.

Summarizing now the results of the above investigation in tabular form, we have the following:

Safe Pressures Per Inch of Diameter and Per Inch of Width of Face of Wheels Rolling on Plane Surfaces.

	Lbs.
Wheels rolling on dirt road	4 to 10
Wheels rolling on good macadam surface, probably	8 to 15
Wheels rolling on stone or asphalt pavement..	20 to 25
Chilled or steel tired wheels rolling on rails..	200 to 300
Rollers of small diameter rolling on smooth cast-iron or steel surfaces	300 to 800

In each case the higher figure may be taken to be the limit at which the material over which the wheel rolls will suffer rapid wear or incipient crushing, and the lower figure may be taken as the preferable one to insure durability of the surface.

So far as we are aware, the above is the first attempt ever made in technical literature to establish a systematic rule for the safe unit pressures of rolling wheels. Very likely some of our readers may take exception to some of the figures and may have data to present in support of their position. We invite discussion and criticism, for the figures as we have set them down are, of course, merely tentative. That the matter is of enough importance to deserve the attention of engineers and the formulating of accepted coefficients for the safe supporting power of various road surfaces seems to us entirely clear.

LETTERS TO THE EDITOR.

How Far Should Established Rules and Formulas be Subject to Criticism?

Sir: Mr. Hewitt's reply in your issue of April 6 to the criticisms of his formula for bending stresses in wire rope is clear, explicit and, on the whole, fair to his opponents and patient and temperate in his treatment of their objections to his theory. He supports his position by citing five other authorities who agree with him, which adds much to the value of the discussion by giving the places where what these authorities have to say can be found. Some of the authorities he appeals to for confirmation are now living and have high rank in the engineering world, those who are now deceased bear a high and well-deserved reputation. But are we on account of the rank and the status and prestige of these distinguished men to reject facts well ascertained by numerous less distinguished men, facts which these less distinguished men are entirely competent to ascertain correctly?

Suppose facts and theory do not agree, which has to yield? What is the history of other sciences in this regard? In astronomy, in geology, in electricity, theories have again and again been revised in order to make the theories fit the facts; and while the old theories have not immediately gone out of use it has been considered a step in advance and genuine progress to bring the theories into better agreement with actual facts and with all the facts. Answering Mr. Hewitt's question "where shall we look for it" (truth) I would say look for it everywhere and take the testimony of everyone who will tell what he knows and do not shut the door on any fact, not even a single one.

Let us have more data on which to base our theories and let no one be deterred from bringing forward new

facts by the fear of being treated as one with no status, no prestige and one who has not a name known the world over. Many humble men know, and know thoroughly well, certain facts that they have learned by experience and yet they keep silent as to these facts, feeling that if they say something that does not accord with the "authorities" it will at once be said "Who are you? what is your rank? are you a chief engineer or merely a draftsman or an instrumentman, or a contractor?" Such an attitude towards these men who know things by experience will result in theory and practice being kept too far apart and in the term "theorist" remaining a term of contempt, which it should not be at all. We need theory, but it should be good theory and above all it should not be arrogant in its attitude towards facts.

Yours truly, W.

Nashville, Tenn., April 8, 1905.

The Practical Result of Depending Upon Individual Citizens to Provide Pure Water for Themselves, as Shown at Columbus, Ohio.

Sir: The following figures are the result of a house to house canvas recently made by the Columbus Board of Health to determine the source and character of the water which was actually used by the residents. The canvas incidentally serves to determine the population of the city which is 171,572, an increase of about 50,000 since 1900. The following statistics were obtained:

Population	171,572
Houses visited	31,373
Houses where city water was used	22,623
Houses where city water was used after boiling	14,087
Houses where unboiled city water was used	8,536
Houses where well-water was used	7,841
Houses where well-water was used after boiling	1,238
Houses where unboiled well-water was used	6,603
Other sources	909

These figures are interesting in that they first show that 37% of those who depend upon the city's water supply do not boil the water; in spite of the fact the warnings have continually been issued by the city Board of Health ever since the severe typhoid epidemic of January-February, 1904. Warnings are also frequently issued to boil all water from private wells, as many such wells are known to be contaminated. The above statistics show that 81% of the well water users, however, have not heeded this warning.

In spite of the fact, therefore, that the health board and the newspapers have been endeavoring for over a year to convince the people of the dangers of using a polluted river, or contaminated wells, and that an epidemic due to polluted water has within a year caused 175 deaths and more than 1,700 cases of typhoid fever, about 50% of the people have taken no means of protecting themselves.

This shows the necessity, in any city, of having a pure public water supply available to all, so that no private wells need be used. It also shows the impracticability of depending upon individual residents to use any care or judgment, or go to any trouble to protect themselves by boiling a dangerous water before use.

The above facts are an argument against the use of a double system of public water supply—one filtered and one polluted—as is, at times, proposed by impractical engineers and others. For if contaminated water were available in a dwelling for any purpose whatever, there would always be a certain number who could not or would not understand the importance of avoiding its use for cooking, washing vegetables, or other domestic purposes. Such people would use the pure or the impure supply whichever happened to be most convenient.

R. Winthrop Pratt.
Engineer Ohio State Board of Health.

Columbus, O., March 20, 1905.

The Relation Between Engineers and Architects.

Sir: Referring to Mr. C. T. Purdy's paper on "The Relation of the Engineer to the Architect," published in Engineering News of Jan. 26, 1905, the writer wishes to suggest a phase of the question as viewed from the architect's standpoint.

The general criticism that is here offered on Mr. Purdy's paper is that a condition more or less accidental is assumed as fixed and finally established. The idea that the structural features of a design are and shall be handled apart from the design seems to be taken for granted. That such a condition does exist to some extent at the present time cannot be questioned; bnt is such a condition desirable and need it or will it continue?

As Mr. Purdy states, the advent of rolled steel shapes in building construction is responsible for modern conditions. When this class of material began to come into general use, the architect was obliged to go outside his own office for assistance, and naturally turned to the bridge engineer who had already acquired some experience in the use of the new material. This method of procedure was natural enough, but one would hardly expect it to produce results of much artistic excellence. The rolled beam has now long ceased to be a novelty and a knowledge of its proportions is now by no means confined to the bridge designer. The architectural schools realized the new demands and arranged their courses accordingly. Professor Ware, late of Columbia University, says that the architectural designer must have a good general knowledge of construction, and the structural designer should be well grounded in the principles of architectural design. The same theory of instruction holds good throughout the architectural schools and will leaven the profession with men whose educational qualifications will make it unnecessary to depend on outside help in solving structural problems.

Mr. Purdy states that a competent engineer is not likely to be content with a position in an architect's office; and, further, that the experience gained in such a position is not likely to develop a good designer. If there is any truth in the first contention, the consulting engineer must be at a loss to secure good assistants for himself unless he succeeds in persuading them that the positions he has to offer are of especial advantage and dignity. The second statement is probably made thoughtlessly, for an architect's office is the only place where it is possible to learn the correct relation of the structural design to the general design of the buildings. The structural problems that arise in the architect's office are of great variety and their solution must be worked out in intimate relation to the general plan and architectural features.

Mr. Purdy speaks of a fear on the part of the architect to allow the structural design to be carried on away from his own personal supervision and then puts the objection lightly aside. This objection, however, is at the very heart of the matter. An inspection of a large modern building in the course of construction and indeed after completion, often shows evidences of a number of minds working at cross-purposes. This condition is perfectly natural with existing methods and can be entirely avoided only by working out all features of the design together and under the supervision of a single mind. When the owner has gained a clear understanding of how the best results are actually to be obtained, he will hardly be willing to entrust an important building project to any save an architect whose training and experience, together with his staff of trained assistants enable him to design the work in all its parts intelligently and consistently. If the architect of the future is to be to a great extent an engineer, let it be so, but he must be trained in all that has heretofore comprised an architect's educational equipment.

A very considerable number of men in the architectural profession are carrying on a line of work in which structural problems by no means predominate and among these the above objection to employing the services of a consulting engineer may not hold. Indeed the foregoing remarks are not intended to apply to the entire field of the relation of the engineer to the architect, but rather to suggest the surest way in which it may reasonably be expected to secure the best aesthetic and practical results in important building operations.

George V. Rhines,
Civil Engineer in the Office of Geo. S. Mills, Architect.

Toledo, Ohio, April 3, 1905.

Discussion of a Court Decision Relating to the Subdivision of Sections of Land.

Sir: The decision of the Supreme Court of Wisconsin in the case of Underwood et al vs. Smith et al, brings up a point in land surveying which seems to have been generally overlooked, as I do not find it mentioned in any of the text-books at my command. The case in question was to determine the east and west subdivision lines of Section 6, where the east quarter post falls in a lake and has not been, and, it is assumed, cannot be fixed. The west quarter post is known and so are all the exterior lines of the section. The court held that:

> The true east and west quarter line of Section 6 is a line running east from the west quarter post in a mesne course between the north and south lines of the section.

The reasons for this ruling are based on: First, the United States statute which says:

> In those parts of the fractional townships where no such opposite corresponding corners have been *or can be* fixed, the boundary lines shall be ascertained by running from the established corners due north and south or east and west lines as the case may be.

Second, on an opinion of the commissioner of the general land office which says:

> The law presupposes the section lines to be due lines, but in actual experience this is not always the case; hence in order to carry out the spirit of the law it will be necessary, in the running of subdivisional lines through fractional sections, to adopt mean courses where the lines are not due lines.

Presumably it was not necessary for the commissioner when he wrote this opinion to call attention to the exceptions to the rule.

There are five sections, 1, 2, 3, 4 and 5, in which the rule does not apply to the east and west lines. There are five other sections, 7, 18, 19, 30 and 31, in which it does not apply to the north and south lines, and one section, 6, where it does not apply at all. In Sections 1, 2, 3, 4, 5 and 6 the law presupposes the south line of the section to be a due east and west line. The quarter posts on the east and west sides of the section are placed at 40 chains from the south line and all the east and west subdivisional lines of these sections are made parallel with the south line, regardless of the course of the north line. This is done under regulations prescribed by the Secretary of the Interior, as provided by Sec. 2397 of the revised statutes of the United States.

Under these same regulations all the north and south subdivisional lines of Sections 6, 7, 18, 19, 30 and 31 are made parallel with the east line of the section, regardless of the course of the range line. The surveys and official plats were made and the lands sold in accordance with these regulations. Hence, in this case, if the east quarter post of Section 6 cannot be fixed, then the court should have held that the true east and west quarter line of Section 6 is a line running east from the west quarter post in a course parallel with the south line of the section.

Every practical land surveyor who has had experience with the United States land surveys knows how extremely rare it is to find the south line of Sections 1, 2, 3, 4, 5 or 6 parallel with the north line, or the east line of Sections 6, 7, 18, 19, 30 or 31 parallel with the west line. In many cases the discrepancy is very considerable, counted by chains rather than by links. The following illustrations are given to show the working of the Wisconsin rule. Fig. 1 represents a section adjoining the north boundary of the township. The west side is longer than the east side. The subdivision lines are marked in accordance with the survey and official plat. Now suppose the east quarter post is so situated in a lake that it has not been, and cannot be, fixed, and a line run east on a mean course from the west quarter post. Fig. 2 shows what would happen; there would be a triangle cut off from the south half and given to the north half of the section, the short side of which triangle is half as long as the difference in length of the sides of the section. Next suppose it is the west quarter post which is missing, and the line run west on a mean course from the east quarter post. Fig. 3 shows the result; a triangle cut off from the north half and given to the south half of the section. What difference it would make in the Wisconsin case I do not know, but as applied to the east and west subdivision lines of Sections 1, 2, 3, 4, 5 and 6 and to the north and south subdivision lines of Sections 6, 7, 18, 19, 30 and 31 the Wisconsin decision is bad law and should not be followed.

F. Hodgman.

Climax, Mich., March 6, 1905.

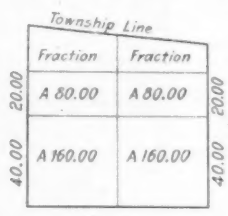


Fig. 1.

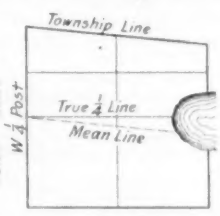


Fig. 2.

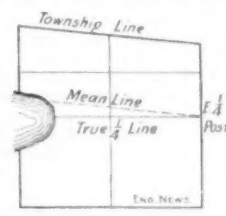


Fig. 3.

The Disintegration of Portland Cement by the Action of Oil.

Sir: In your issue of March 16, 1905, Mr. Jas. C. Hain had a most interesting article on the "Disintegration of Portland Cement Briquettes by Oil and Experiments to Prevent It," and my attention was promptly called by a well-known engineer to this article. Mr. Hain was kind enough to send me a briquette which had been treated with signal oil, and as I inferred that the disintegration was due more to chemical action than to physical changes, I determined without delay to make some experiments.

In looking over Mr. Hain's list it was very easy to see that the organic and animal oils decomposed cement concrete and that mineral oils had little or no effect. We therefore made a determination of the soluble substances in the briquette and found that the disintegration was due to the formation of oleate and stearate of calcium. To reduce this to its simplest expression the animal oils contain acids which combine with the lime and crystals of stearate and oleate of lime are formed. It is very likely that these crystals in the process of formation have increased the bulk in the briquette and the bond which has been formed by the lime in the set cement, has been totally disintegrated and ruptured.

It will be of interest to know that we isolated these crystals and then proceeded to verify them under the microscope.

It is also evident from the results of Mr. Hain that boiled linseed oil has practically no effect on cement. This has been known for quite a time, the reason being that the outer film absorbs oxygen and dries the oil rapidly; but as no experiments were made with raw linseed oil, it is reasonable to infer that this oil might in time have a deleterious effect on certain forms of concrete. In fact I know that raw linseed oil will injure a concrete rich in lime.

Machinery oil which contains no animal oil is evi-

dently harmless to cement concrete for the reason that no combination can occur. Machinery oils are almost exclusively paraffine oils.

The suggestion that a cheap wash be invented which would directly protect concrete from oil is quite opportune, but such washes are generally not cheap. In the experiments made by both Hauenschild and Kessler fluosilicate of magnesia is recommended, which is sold in this country under the name of Fluate and when this is applied to cement concrete, silica is liberated which fills up the pores. The magnesium fluate acts as a binder and the cement becomes extremely hard after some months. Limestone and building stones in general have been treated with this material in Europe with great success.

Another method which has been successfully employed, particularly in the large power houses where electrical machinery of great value is operated, is the treatment of the floors with a coating of a resin liquid made from kauri gum which takes up the lime and permeates the cement. Over this a coating of a similar material is applied containing pigment, and such a floor is proof against both machinery oil and water and will not dust up or powder eventually.

The question as to whether these applications are cheap is an economic one, because if they do their work successfully and make a floor dustproof and save the armatures and contact points of electrical machinery, they are cheap at almost any price. The relative value of an application of this kind, however, is not to be underestimated, in view of the fact that where animal oils may come in contact with a floor, disintegration, as described by Mr. Hain, would be very dangerous.

Prof. Tetmajer in his "Hydrauliche Bindemittel" on the influence of petroleum on the cohesion of cement, page 23, gives very interesting details on the tensile strength of cement treated with petroleum oils, and naturally omits any comment on the chemical combination between petroleum and cement.

Maximilian Toch.

Laboratory of Toch Brothers, Long Island City, April 10, 1905.

The Respective Levels of the Pacific and Atlantic Oceans.

Sir: In your issue of March 16, Mr. John F. Hayford discusses in connection with a discrepancy of about 7½ ins. in the trans-continental leveling, the question whether the mean level of the Pacific Ocean is higher than that of the Atlantic.

Such a question is a prima facie *reductio ad absurdum*. That two connected bodies of water at rest should be at different levels, seems to be a self evident untruth. If the average level of the Pacific was higher than that of the Atlantic, a current would set from the former to the latter, which would equalize the levels. Of course it is well known that such a current exists around Cape Horn, but nobody attributes this to a difference of levels, and if it were so attributed we should have to find a source of the permanently higher level in the Pacific, in other words some natural pumping engine to restore by some subterranean or aerial passage the waters of the Atlantic to the Pacific. Again, were the waters of the Pacific higher than those of the Atlantic, there would be a permanent eastward current through Behring Straits and the Arctic Ocean, and no such current is known to exist. Such a discussion is then on its face rather foolish. Still it may be admitted that there is a question involved which might account for a permanent discrepancy in the measurements between the Atlantic and the Pacific; but before it can be discussed it is necessary to have clearly in mind what we mean by a level surface. Assuming as a simple definition that it is a surface at all points perpendicular to the plumb line, then, as is well known to geodetic surveyors, such a surface will not be a precise ellipsoid of revolution concentric with the earth, since the plumb line is caused to deviate by proximity to mountain masses, and does not by any means invariably pass through the earth's axis. While then it may be granted that the mountain masses on the western side of the continent may cause a heaping up of the waters on this side in such manner that the water surface of the Pacific adjacent to the coast will be farther from the earth's center than the surface at the corresponding latitude on the Atlantic, still the two bodies of water would be at precisely the same level. Nor could such difference in distance from the center of the earth be determined by geodetic instruments, since all of those in common use use the spirit level, whose indications depend on the direction of the plumb line at the point where the instrument happens to be. It would seem therefore that, owing to the undulating nature of the level or equipotential surface in which the instruments are set in crossing the Rocky mountains, it would be impossible to obtain a precise and unvarying result for the comparative relation of the two ocean-levels which would be independent of the points at which the instruments happened to be set up. In other words, another line of levels run across a different section of country would give a different result, and the difference would not accrue from errors of observation, but from the irregular deviation of the plumb line at the different points of the surface.

With these considerations in view, the discrepancy of seven or eight inches, more or less, in the line of levels seems rather small than large, even assuming that each observation was mathematically correct.

Another point for consideration in this connection is, what is apparently shown by the readings for mean tide level at Sandy Hook and other points, that there exists a certain long-period and probably irregular tide or fluctuation between the two oceans, whose period may extend over several years, thus making an extended series of observations necessary to determine for a certainty the true mean annual tide level for any period.

George W. Colles.

Milwaukee, Wis., April 7, 1905.

The Pressures on Culverts in High Embankments.

Sir: In your issue of March 9, 1905 (p. 259), Mr. Geo. R. Winslow asks for a discussion of "How Should the Load of a Culvert Under a High Embankment be Computed?" His authorities are all perhaps right under certain conditions. I think there is, however, a very common misconception about the conditions which are the result of ordinary practice in constructing embankments with their accompanying culverts.

In the accompanying sketch (Fig. 1) I have shown an ordinary 6 x 4-ft. stone box under a 40-ft. embankment. I think it is safe to say that the majority of such fills are made by dumping from a trestle. In that case the fill will be carried up approximately horizontal along the axis of the roadway. As a result the material falls loosely in place, more particularly at the bottom, as most of the clods and chunks bring up at the foot of the slope as the fill is built up. Under those conditions let the fill be completed and the final settlement take place. The greatest pressure, and the coarsest, loosest material being on the bottom, the greatest settlement will take place there. But the box stands as an incompressible unit for its entire height. Therefore as the material in the zone below E A and B F settles past the sides of the box it will not only develop friction against them, but will also tend to settle away from the particles directly above the box. The friction and cohesion developed will throw additional weight on the box. The amount of course will depend on the character of the material. Dry sand would throw very little additional weight on the culvert, while tough clay might cause the line of cleavage to stand out at a slope of nearly 1 to 1 for a time. Of course when the final settlement is reached the cleavage lines would perhaps stand nearly vertical. The settlement of the bank which would tend to produce the above result is shaded in the figure.

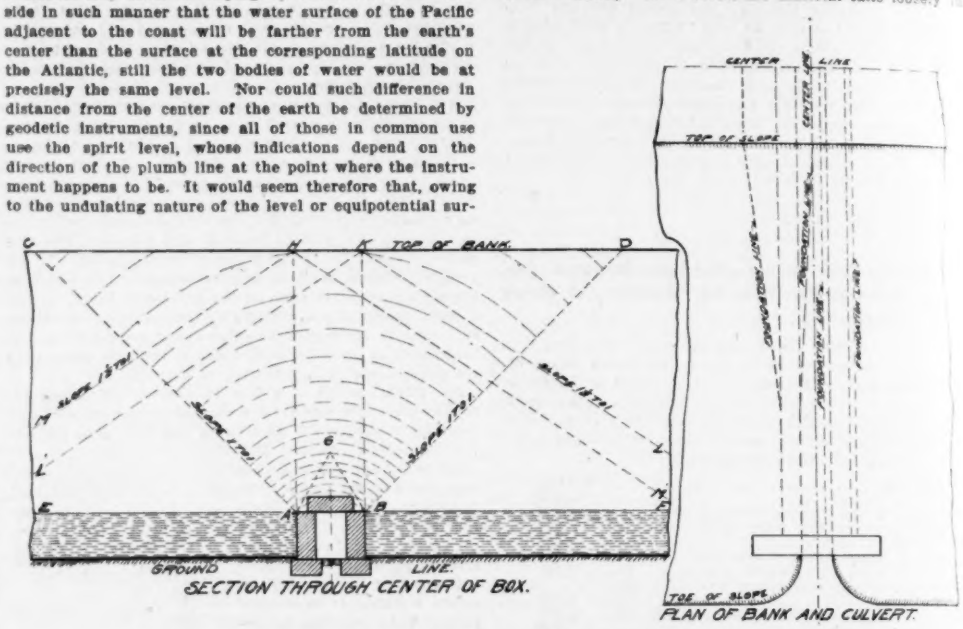


FIG. 1. PRESSURES ON CULVERTS IN HIGH EMBANKMENTS.—C. K. Mohler.

To show that the lines of cleavage may take as great an inclination as shown, imagine what would take place if you were suddenly to lift the box vertically through a well compacted bank. It certainly would not shear out a prism A H K B. The first movement of the earth above the culvert would be a radial compression somewhat as suggested by the curved lines. On the other hand, if you tunnel through an old bank, say to rebuild an old timber box with stone, you may have the condition indicated by the lines A G — G B. Here if the roof is supported, and then back-filled and slightly tamped above the cover, there may little if any pressure develop greater than the weight of the material inclosed by the lines A G — B G. From the above it will be seen that the load carried by

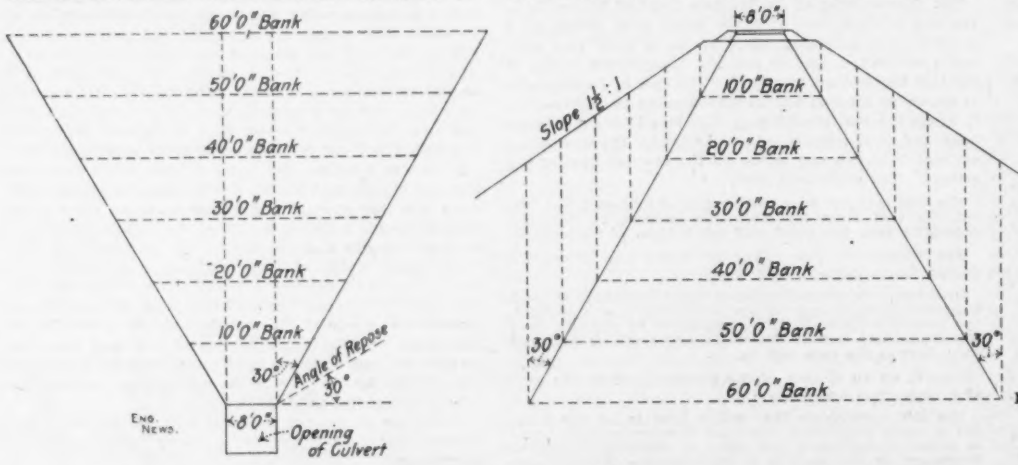
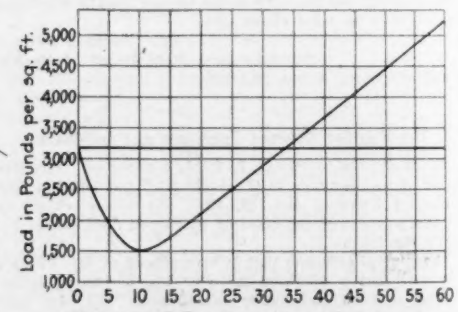


FIG. 2. PRESSURES ON CULVERTS IN HIGH EMBANKMENTS.—M. F. Clements.



Loads in Pounds per Square Foot on Top of Culvert.

Height of bank.	Dead load.	Live load. (E 50)	Impact.	Total.
0	60	1,560	1,560	3,180
10′	1,024	515	.....	1,539
20′	1,865	290	.....	2,155
30′	2,727	187	.....	2,914
40′	3,549	138	.....	3,687
50′	4,363	107	.....	4,470
60′	5,176	88	.....	5,264

the box may be only a fraction of the load vertically above it, or it may far exceed the load of the vertical projection, spreading out on the lines A C and B D or even taking a greater load for a time.

To prevent excessive settlement of the box or arch under the high part of the bank, the breadth of the foundation should be increased somewhat as shown in the left half of the plan in the sketch, Fig. 1. That was spread to distribute the embankment load at the rate of 2,000 lbs. per sq. ft. of foundation. It is needless to say that the common method is that shown on the right half of the plan and as shown in the cross-section.

Aside from the effect of jars and vibrations produced by the live load, its effect can almost be neglected. If you have a concentrated load, say at K, the load will be distributed throughout the volume of a cone the inclination of the surface being about 1½ to 1, as shown by K L and K L'. For the above case the box would receive a unit of live load pressure only when the live load extends for 60 ft. each side the culvert. On that basis the live load pressure of two 100-ton locomotives would be only a little over 0.01 ton per square foot of foundation.

Yours truly, C. K. Mohler.

1980 Washington Boul'd, Chicago, Ill., March 20, 1905.

Sir: In answer to the inquiry of Mr. Geo. R. Winslow, in your issue of March 9 (p. 259), in regard to earth pressure on top of culverts in high embankments, I wish to add a word. Owing to the fact that past investigations have not added materially to our knowledge of earth pressures no one of us can submit a fact and say that this is the true result and that we have proof wherewith we speak. I will try to submit a method which seems reasonable to me, but not with the idea of presenting anything original. This method is to supply information for a load on a culvert in a railway embankment whether it be high or low.

During the last few years the railways in the middle west have suffered materially from washouts. Banks which have been standing for years became saturated to such an extent that they fissured and slid off in such a manner as to show that adhesion was at the point of rupture. The sliding in any embankment is in the direction of the slope and the amount depends upon the depth of the saturation. In a high bank I would say that there is an arch action the amount of which is more or less a speculation, but in low banks, below 20 ft., the amount of the saturation in very wet weather is sufficient to cause rupture in almost any direction, and for comparatively low banks the weight of the earth directly above the culvert should be considered in the design. Assuming the method that I give later to be correct, a culvert designed for a live load with no ballast between the tie and the top of the culvert and proper impact will receive no greater load in a bank with a 33-ft. depth over the top, which is equivalent to a 40 or 45-ft. fill. This is an ordinary high embankment in the middle west. Above this height I believe the arch action in the filling material would be sufficient to protect the culvert from any greater load.

As to the action of the pressure due to live load through the material of an embankment, I can only present a method which seems rational to me.

We have the assumption of Rankine and others in regard to earth pressures against a vertical surface, such as a retaining wall, that the wedge of earth which brings the maximum pressure against the vertical surface is that next to the vertical surface included between lines which have an angle between them equal to one-half the complement of the angle of repose of the filling material. In the diagram herewith (Fig. 2) I have assumed the angle of repose to be 30° and the effective wedge of greatest pressure against the vertical plane would be included between the lines as shown, which make an angle of 30° with the vertical. It is through these wedges and the material directly above the culvert (assumed to be an 8-ft. span) that any effect of the live load can be transferred. Compute the equivalent uniform load for the length of span directly over these wedges and culvert opening for the various depths of bank and distribute these over a base included between lines making an angle of 30° with verticals dropped from the ends of the tie. In this way a live load for various depths of bank can be computed and tabulated. For dead load I have assumed the weight of the earth in a cross-section of the embankment directly above the base over which the live load was distributed and bounded by vertical lines in a direction across the culvert. The weight of earth is assumed to be 100 lbs. per cu. ft. I have assumed impact to be 100% with no fill and zero with a 10-ft. bank. The sum of these results will give loads per square foot on top of the culvert.

Under these assumptions we find that the variation of impact is of no consequence and that a culvert with a 33-ft. embankment over the top has no greater load than a culvert with no filling. For culverts of greater depth, the arch action of the filling would be sufficient to keep the pressure below this limit. For convenience, I think a uniform load per square foot can be assumed for all conditions and depth of bank. The assumed live load with its impact will give all the information necessary.

Very respectfully,

M. F. Clements, C. E.,
Asst. Engr., C., R. I. & P. Ry.

Cedar Rapids, Ia., March 21, 1905.

Handy Rules for Safe Loads of Steel and Timber Beams

Sir: A method by which the safe loads for steel I-beams and rectangular wooden beams can be closely approximated with little more than mental calculation was devised by the writer some time ago, and has been found very convenient for checking designs of beam work and for determining the capacities of beams when a book of tables is not at hand. It may, perhaps, be of use to some of your readers and is given below.

The procedure is to first find the safe load for the given beam for a span equal to twelve times the depth of the beam, and then the safe load for the given span follows from this by inverse proportion, since the capacity of a beam varies inversely as the span. This particular span (i. e., 12 times depth of beam), may, for sake of a name, be termed the "normal" span of the beam, and is of a length in feet numerically equal to the depth of the beam in inches.

Taking the safe fibre stress for steel beams at 16,000 lbs. per sq. in., we have the following rule:

RULE 1.—The safe load in pounds, uniformly distributed, for any light weight I-beam over its "normal" span, is approximately equal to the weight of beam per lineal foot multiplied by 1,000.

Example.—Required the safe load, uniformly distributed, for a 15-in. 42-lb. I-beam over a span of 20 ft. By the above rule the safe load for this beam over its "normal" span (15 ft.) is $42 \times 1{,}000 = 42{,}000$ lbs., and for a span of 20 ft. we have $42{,}000 \times \frac{15}{20} = 31{,}500$ lbs. Carnegie's tables give 31,420 lbs.

The error in the results obtained by this rule varies for different depths of beams. For beams under 15 ins. in depth the rule gives values too small by 1.5% to about 6%. For the larger sizes of beams the values obtained are too great by 2.3% to 6%.

The rule as stated above applies only to the lightest weight beam from any set of rolls, it being remembered that 12-in. and 20-in. beams each have two shapes and consequently two light weights, viz.: 31½ and 40 lbs. per ft., and 65 and 80 lbs. per ft. respectively, and that for the 15-in. depth there are three light weights, viz.: 42, 60 and 80 lbs. per ft. For the heavier weight beams the rule is changed somewhat. Inasmuch as the heavier weights are produced by merely spreading the rolls, the added sectional area goes entirely into the web, and is, therefore, in the shape of a rectangle of a depth equal to that of the beam. The efficiency of the metal in this rectangle to resist bending is about one-half of that of the metal in the form of the light weight I, which fact is provided for thus:

RULE 2.—For a heavy weight I-beam the approximate safe uniform load in pounds over "normal" span is found by multiplying the mean between actual weight per foot and that of the lightest weight beam for the same rolls by 1,000 (the maximum fiber stress being 16,000 lbs. per sq. in.)

Example.—The safe load, uniformly distributed, for a 24-in. 100-lb. I-beam over its "normal" span (24 ft.) is approximately $90 \times 1{,}000 = 90{,}000$ lbs., since 90 is the average of 100 (the acual weight) and 80 (the weight per foot of the light 24-in. section). The error in this case is +2.6% comparing with Carnegie's tables.

Rules similar to the above apply to channels, the multiplier being 940 instead of 1,000 since channels are less efficient than beams of the same depth. Using the factor 940 for channels gives results with a maximum error of about ±4½%.

In the case of wooden beams the rule takes account of the sectional area of the stick instead of the weight per foot, and is as follows:

RULE 3.—The safe load in pounds, uniformly distributed, for a rectangular beam over "normal" span is equal to the sectional area of beam (in square inches) multiplied by $\frac{1}{9}$ of the safe fiber stress (in pounds per square inch).

Thus for a fiber stress of 1,200 lbs. per sq. in. the multiplier is $\frac{1{,}200}{9} = 133\frac{1}{3}$, and similarly for a 1,000-lb. unit stress the multiplier is 111.

Example.—Required the safe uniform load for an 8 × 12-in. timber with a span of 18 ft., maximum fiber stress 1,200 lbs. The beam lies with its 12-in. side vertical, and therefore the "normal" span is 12 ft. The sectional area of beam being 96 sq. ins., we have for the safe load over 12-ft. span, $96 \times 133\frac{1}{3} = 12{,}800$ lbs., and for 18-ft. span $12{,}800 \times \frac{12}{18} = 8{,}533\frac{1}{3}$ lbs.

The results by Rule 3 are exact, since the formula follows directly from the ordinary equations of beam flexure. Consider the section of a rectangular beam of breadth b and height h and area A = bh. Then, Moment of Inertia about neutral axis = I = $bh^3 \div 12$, and section modulus

$$S = \frac{I}{e} = bh^2 \div 6 = Ah \div 6 \qquad (1)$$

in which e is distance from neutral axis to outer fiber, and in this case $e = \frac{h}{2}$.

Also, Bending moment $M = \frac{Wl}{8} = pS = p\frac{Ah}{6}$

hence

$$W = \frac{8}{6}\frac{p\,Ah}{l} \qquad (2)$$

Where p is the stress in the outer fiber in pounds per square inch, W = the load on beam in pounds, uniformly distributed, and l = length of span in inches.

Giving l in (2) the value 12h (which has been termed the "normal" span) we have

$$W = A\frac{p}{9} \qquad (3)$$

as expressed in Rule 3. This formula applies, of course, to rectangular beams of steel or of any other material as well.

The sections of light weight I-beams are so proportioned that their moments of inertia bear an almost constant relation to the moments of inertia of rectangles of equal areas and depths. That is, the moment of inertia of a light weight I-beam is approximately 1.91 times that of a rectangle of the same depth and area. This 1.91 is the mean value of the coefficient, the extreme variation being about 7% above and below this mean, for the entire range of sizes of light weight I-beams. Then applying this coefficient to equation (3) we get, for light I-beams (over normal span), approximately,

$$W = 1.91 \times A\frac{p}{9} = 0.2122\,Ap \qquad (4)$$

For steel beams, however, it is more convenient to deal with the weight per lineal foot than the sectional area of beam. Since w, the weight of steel per lineal foot, is equal to 3.4A, we have from (4)

$$W = w\frac{p}{16}\ \text{(very nearly)} \qquad (5)$$

When the fiber stress p is taken at 16,000 lbs. per sq. in. the expression (5) becomes W = 1,000 w, which is the algebraic expression of Rule 1.

It should be stated that the above rules and equations relating to steel I-beams and channels are based on the properties of American Standard shapes.

Yours very truly, Victor H. Foss,
Engineer, Reid Bros.

Claus Spreckles Bldg., San Francisco, Cal.,
March 14, 1905.

Questions Used in the Examination for Assistant Civil Engineers on the Panama Canal Work.

Sir: In view of the importance of the contemplated work, civil engineers in general may be interested to know what questions were asked at the recent examinations held for assistant civil engineers on the Panama Canal. The positions open to competition carried salaries as high as $3,000 and some prospect of further increase later. The examinations were held by the U. S. Civil Service Commission at a large number of cities throughout the country and were open to all citizens who were properly qualified.

It is against the rules of the examiners to carry any paper away from the examination room, and the questions are rarely published. On that account I am offering you this copy which was furnished me by one of the candidates. The questions were written down by him from memory after leaving the examination, and are therefore more or less incomplete and inaccurate. They will, however, serve to show the character and scope of the examination.

Respectfully, H. L. C.

Chicago, Ill., March 17, 1905.

(The list of questions enclosed follows.—Ed.):

EXAMINATION FOR ASST. CIVIL ENGINEERS, PANAMA CANAL, JAN. 30 AND 31, 1905.

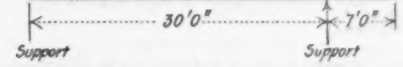
Relative weights:

Mathematics	20
Instruments	10
Surveying	10
Design and construction	20
Training and experience	40
	100

Two days of 7 consecutive hours each. First day, Mathematics and Instruments; second day, Surveying and Design and Construction.

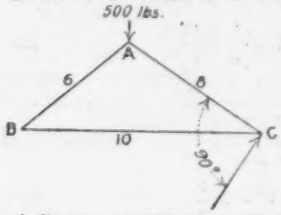
Mathematics.—Answer 3 and only 3 of the following:

1. Given the beam in sketch under a distributed load of 150 lbs. per ft., with dead load of 30 lbs. per ft. (linear) and carrying two concentrated loads as indicated:

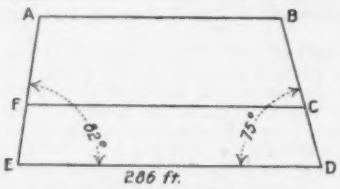


(a) Construct shear diagram.
(b) Find point of maximum moment and amount of same.
(c) Assuming width of 6 ins., section rectangular, and maximum allowable fiber stress of 800 lbs. per sq. in., what should be the depth of beam?
(d) What would be the maximum horizontal shear? (Answer any three parts of this question.)

2. (a) A ladder 30 ft. long leans against a wall. The ladder weighs 50 lbs. A man weighing 150 lbs. and carrying 75 lbs weight is ⅓ way up the ladder. Find reactions of ladder when (1st) it is hinged at top and (2d) when it leans against the wall and friction with wall is zero. (Height of ladder top not given by candidate — overlooked probably.)



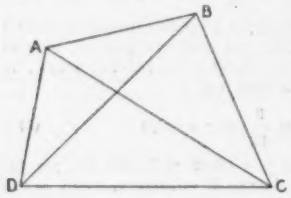
(b) In the pin-connected truss, sketched, find the amount of reaction at "C," amount and direct'on at "B" for equilibrium and find stress in each member.



3. In the figure given B D = 42 ft.
E D = 286 ft.
∠ D = 75°
∠ E = 82°

Find length of frontages B C, C D, E F, and F A to hundredths of a foot when area A B C F is twice as large as area C D E F. Four place logs were supplied.

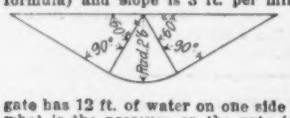
4. Given (see sketch) D C = 1,200 ft. and azimuth of D C = 188° 40'; az. of D A = 97° 16'; az. of D B = 130° 04'; az. A C = 30° 23'; az. B C = 76° 10'; find the length and azimuth of A B.



(Origin and rotation of azimuth not stated; evidently to be determined from sketch.)

5. The sketched figure representing a cross-section of a channel.

(a) Find discharge when running full if C = 120 (in formula) and slope is 3 ft. per mile.



(b) Find size of rectangular section for equivalent discharge if height is ⅔ of base (running full).

(c) If a canal lock gate has 12 ft. of water on one side and 4.2 ft. on the other what is the pressure on the gate (effective); where is the center of pressure, and what would be the initial velocity on raising the gate 6 inches?

6. Candidate did not remember definitely. It had to do with surveying and latitudes and departures.

Instruments.—Answer three only.

1. A transit telescope is said to be achromatic, have no aberration, must have a flat field (and various other terms. Define each term.

2. Tell how you would care for an instrument to keep it in good order.

3. How would you use a transit to correct for instrumental lack of adjustment in the following cases:
(a) Prolonging a line.
(b) Measuring horizontal and vertical angles.

4. Given the formula for stadia measurement, K s + d, show how it is derived and how applied.

5. Draw with pen and ink a longitudinal sketch of a telescope, showing the lenses and other parts; and larger scale sketches to show the relative positions of lenses and the shape of same.

6. Forgotten.

Surveying.—Answer three only.

1. How would you proceed to establish a base line in a tract of land 5 miles by 1½ miles, broken by woods, ponds, streams, etc., to a correctness of 1-50,000?

2. Having completed that work, how would you fill in your intermediate details? Using a transit reading to 20" what degree of accuracy would you seek to obtain?

3. Describe how you would set about to obtain 2 ft. contours to plot to a scale of 1-1,200.

4. If the above is not according to your idea of procedure, describe in detail what you would do to obtain the necessary information.

Design and Construction:

1. Write specifications for concrete under water or on a wet subsoil; and give the tests required for each kind of material. This is to test the writer's knowledge of specification writing.

2. Describe what, in your opinion, is the best kind of street pavement. Draw sketches to show the pavement, sidewalks, sewers, drains, water, gas, etc.

3. A dam is to be built across a valley and the water level is to be 30 ft. above the thread of the valley. The soil consists of 6 ft. of sandy clay over an indefinite depth of stiff gravelly clay. Make a sketch of an earth or masonry dam you would build to impound the water.

4. How would you drive piles in
(a) Shifty sandy soil?
(b) Gravelly soil?
(c) Stiff clay?
What precautions would you take? What length of pile would you use? How would you determine the bearing value of a pile in each case?

5. To design a wooden truss to carry a given load over a given span.

6. Forgotten.

Additional Manufacturers of Machines for Making Concrete Blocks.

Sir: In looking over your issue of April 13 my attention is drawn to the "List of Manufacturers of Concrete Block Making Machines," in connection with which you ask for notice of any omissions. While the names you have presented seem to pretty well cover the field, we would suggest as possible candidates for addition to your list the names of the following concerns which we have on our list:

Keystone Hollow Cement Block Machine Co., Phoenixville, Pa.
Hartwick Concrete Block Machine Co., 227 Washington St., Jackson, Mich.
Frost Concrete Stone Co., Waterloo, Iowa.
Perfection Block Machine Co., Sioux Falls, S. D.
Bright & Co., No. High St., Columbus, Ohio.
Auburn Concrete Machinery Works, Auburn, Ind.
Fishers Hydraulic Stone System, Memphis, Tenn.
Concrete Hollow Wall Construction Co., 1520 Ashland Bk., Chicago, Ill.

In the hope that these may be acceptable, I remain,

Yours truly,
Editor "Carpentry and Building."

New York, April 14, 1905.

Notes and Queries

H. J. D., Albany, N. Y., writes:

S. D. B., on page 362, Vol. LIII, of your paper seems to know of no simpler geometrical proof, of the prismoidal formula, previously published.

I would respectfully refer him to page 314 of "Plane and Solid Geometry" by Beman and Smith, where the method used is exactly similar to his.

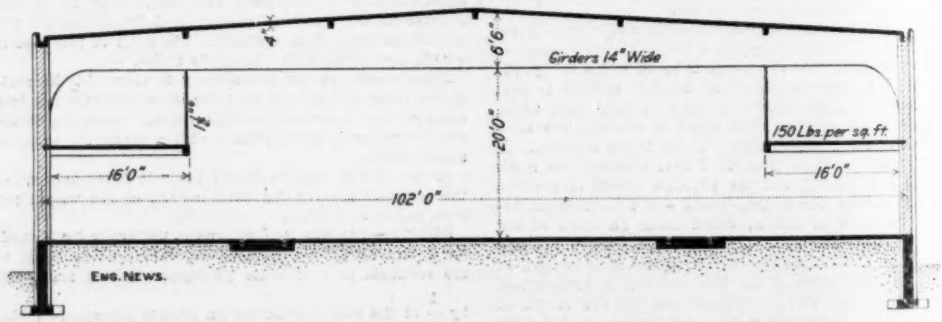
A correspondent desires to know whether concrete has ever been used for the walls of coke ovens, the concrete walls being lined of course with fire brick. Any of our readers who may know of such use will confer a favor by writing us where it was and with what results it was followed.

In reviewing a catalogue of Messrs. H. W. Caldwell & Son, of Chicago, in our issue of April 6, p. 130, it was listed as a catalogue of "Riveting and Conveying Machinery" instead of "Elevating, Conveying and Power-Transmitting Machinery," as intended by the writer of the review.

A REINFORCED CONCRETE ROOF WITH A CLEAR SPAN OF MORE THAN ONE HUNDRED FEET.

In designing mill buildings of reinforced concrete, or in fact any building in which large open spaces are desired, the most difficult problem is the roof construction. A building may have floors and walls built of incombustible materials throughout; but if it is covered with a roof supported by either timber or steel roof trusses, it is doomed to almost inevitable destruction if a fire once gains full headway.

There is, of course, no difficulty in making a concrete roof construction of small span; but when it is desired to leave large open spaces unobstructed by columns or partitions, the roof becomes by far the heaviest and most expensive part of the building. Nevertheless, it is quite possible to make a reinforced concrete roof to cover large spans, and we illustrate herewith a recent example of such construction.



FIREPROOF WAREHOUSE OF REINFORCED CONCRETE WITH ROOF OF 102-FT. SPAN AT LOS ANGELES, CAL.

The engineer who designed the structure, Mr. L. J. Mensch, Monon Building, Chicago, has furnished us the following description:

The Leonardt Warehouse, situated at 6th St., east of Alameda St., Los Angeles, Cal., covers an area of 104 x 150 ft., and was intended to be built of 17-in. brick walls with 25-in. piers, spaced 16 ft. 6 ins. on centers and covered by a steel truss and corrugated iron roof of 100 ft. span.

The owner inquired of the writer whether it was practical to build an arched reinforced-concrete roof instead of the steel construction. Considering that the roof had to carry a suspended gallery and that means had to be provided for lifting heavy weights and eventually to suspend tracks for light traveling cranes, the writer discarded the idea of an arched roof and decided on straight girders of 102 ft. span.

The accompanying cut shows a cross-section of the warehouse as it was built. The girders are 16 ft. 6 ins. apart, 6 ft. 6 ins. deep at the center and have a slope of 3 ft. towards each end. They are 14 ins. wide and reinforced at the bottom by ten 1½-in. steel rods of medium steel, two of which are straight, the others bent up to a hog chain form, all secured to the concrete by 1-in. No. 14 stirrups from 8 ins. to 24 ins. apart. The top is reinforced by three 1½-in. rods, 66 ft. long. Heavy stirrups connect these girders with 24 x 24-in. concrete piers reinforced by five 1⅜-in. rods at the outside and two 1-in. rods at the inside. This gave a skeleton construction and allowed of a reduction in the thickness of the walls to 12 ins.

Hollow concrete block walls were adopted, and were carried by 14-in. concrete foundation walls 8 ft. deep. These walls were enlarged at each pier, and reinforced by ten ⅝-in. rods placed horizontally near the top.

The ground consisted of loose sand, and as serious settlements were found in nearby buildings, only a ton per square foot was assumed as the resistance of the ground. Therefore the footings for the walls were made 3 ft. wide and those for the piers 7 ft. square, all 12 ins. deep and reinforced by ⅝-in. steel rods.

The saving in the walls and footings more than counterbalanced the slight increase of cost of the concrete girders over the steel trusses. The girders were connected by 6 x 11-in. beams reinforced by four ¾-in. rods and covered by 4-in. roof slabs reinforced by ⅝-in. rods 6 ins. on centers in both directions. For the waterproofing, an ordinary composition roofing was used.

There are six sheet-metal and wire glass 6 ft. x 16 ft. skylights in the building. Two galleries 16 ft. wide and 120 ft. long are suspended from the roof girders by 1¼-in. rods. These galleries consist of 8 x 12-in. beams 16 ft. 6 ins. on centers, and a 3-in. floor slab. They are figured for a load of 150 lbs. per sq. ft.

The erection of the building was very rapid and it was built in a shorter time than the delivery of steel trusses could be assured on. It took about two weeks to erect the centering and one week for the concreting.

The concrete was mixed in the proportion of one part Iola or Colorado cement to 1½ parts of sand and 3 parts of crushed granite in the lower portion of the girders, and 1:2:4 for all other parts.

These girders of 102 ft. span are the largest ever attempted and it is believed that there does not exist another fireproof roof of such a great span.

REPORT OF THE CHIEF ENGINEER OF THE ISTHMIAN CANAL COMMISSION.

Rear Admiral John G. Walker, U. S. N.
Chairman, Isthmian Canal Commission,
Washington, D. C.

Sir: I have the honor to submit the following report of the engineering and construction work, under the direction of the Chief Engineer, from the date of his appointment, June 1, 1904, to February 1, 1905, the report being rendered as of the latter date in order that the Commission may have a condensed record of progress and the necessary data and facts to enable it to reach a determination on the essential features of the project.

METHODS EMPLOYED PRIOR TO JULY 1, 1904.—The Chief Engineer found the following engineers stationed at various points along the canal:

Mr. Charles List and party, at Colon; Mr. A. B. Nichols and party, at Gatun; Mr. H. F. Dose and party, at Bohio; Mr. Boyd Ehle and party, at Bas Obispo; Mr. A. C. Harper and party, at Culebra.

These parties were employed by the Commission about June 1, 1904, and were instructed to conduct certain technical studies, surveys and investigations in the localities mentioned, but owing to a delay in receiving boring apparatus and other supplies, no progress was made along these lines prior to July 1.

At Culebra the Chief Engineer found that the organization and methods of the New French Company had been continued. This work was under the immediate charge of Mr. A. C. Harper as resident engineer, assistant to Col. Black.

ORGANIZATION OF THE ENGINEERING AND CONSTRUCTION DEPARTMENT.

The Chief Engineer immediately gave his principal attention and supervision to the work of the various engineering parties in the field; outlining methods for the future conduct of the engineering and construction features and the preliminary organization of his general staff.

MECHANICAL DEPARTMENT.—Mr. Carl A. Strom, Mechanical Engineer, who had previously arrived on the Isthmus, was placed in charge of the care, repair and maintenance of all machinery and equipment, and was instructed to proceed at once with the organization of his Department.

SUPERVISING ARCHITECT'S DEPARTMENT.—Mr. M. O. Johnson was employed as Supervising Architect and instructed to perfect an organization for the repair and maintenance of existing buildings, as well as the preparation of plans and estimates and supervision of construction of such new structures as might be required in the future, and his Department has been organized to that end.

DEPARTMENT OF WATER-WORKS AND SEWERS.—Mr. Carleton E. Davis, engaged by the Commission as Engineer in charge of water-works and sewers, upon reporting to the Chief Engineer on the Isthmus, was assigned to the duty of investigating and reporting upon the plans for the construction of sewerage and water supply at Panama and Colon and at such other points along the line of the canal as it might be found necessary to have works of this kind.

QUARTERMASTER'S DEPARTMENT.—Under the direction of the Chief Engineer, the immediate supervision of pay-rolls, the assignment of quarters, the handling of requisitions, the record of employes, and other matters of a similar nature, were placed under Capt. Edward L. King, U. S. Army, who was instructed to organize a force for the proper conduct of this work.

MAPS, LITHOGRAPHING AND PRINTING DEPARTMENT.—A department of maps, lithographing and printing was organized under Mr. C. Bertoncini, who had previously had charge of work of this character under the French administration.

INSTRUMENT REPAIR SHOP.—The repair of engineering instruments and such other mechanical and electrical work as was necessary was placed under the immediate charge of Mr. M. Regis, reporting to Mr. Bertoncini.

GENERAL.—The heads of these various sub-departments, and the resident engineers in the field, reported direct to the Chief Engineer, whose immediate office organization consisted of an office engineer, Mr. W. J. Karner, and Mr. John F. Seager, Private Secretary, with such stenographers and clerks as were necessary for the conduct and general supervision of the work. This organization has been perfected from time to time, and through it the Chief Engineer maintains administrative and executive control.

PROGRESS SINCE JULY 1, 1904.

The progress of the work from its inception to date has been as follows:

MR. CHARLES LIST, RESIDENT ENGINEER, CRISTOBAL.—Mr. List has been engaged upon surveys, technical examinations and other work on that portion of the canal between Gatun and Colon, including Colon Harbor. The general result has been that sufficient facts have been secured to determine the location of the canal in the vicinity of Colon and the plan of operation, including the necessary wharves and docks. Plans and estimates were furnished the Engineering Committee during its presence on the Isthmus, and the same are recommended to the Commission, providing for—

1. The construction of a breakwater for the protection of Colon harbor;
2. A direct entrance into the canal line;
3. The construction of an inner harbor at Cristobal-Colon;
4. The completion of the construction of the Gatun diversion.

It is believed that ample information has been obtained, and the details furnished, on which to base a decision as to the general features of the principal problems connected with the harbor, the entrance to the canal, and the Gatun diversion.

MR. A. B. NICHOLS, ASSISTANT ENGINEER, GATUN: THE GATUN DAM.—The primary object of the examinations under Mr. Nichols was to determine the possibility of a dam across the Chagres Valley in the vicinity of Gatun, forming a lake the surface of which would be approximately 60 ft. above the level of the sea, as this had been suggested as a possible alternate plan.

The valley in the general vicinity of Gatun is approximately a mile in width, and examinations and trial borings have been made on every locality which gave any indication of promise. While some form of rock or indurated clay has been found near sea level at certain points in the valley, further exploration along the line has always found a deep gorge filled with alluvial deposits and freely water-bearing material at such depths as to preclude the economical or safe construction of a dam in this general vicinity; and from facts developed in other parts of the valley, it seems evident that bed rock will not be found at any less depth than 163 ft. below sea level at any point north of Bohio. While it is barely possible that at some point a dike of rock may exist across the valley, due to volcanic upheaval, it is highly improbable.

The results of all the studies in the Chagres Valley from Gamboa to Colon clearly point to the existence of a geological gorge, the bottom of this gorge being at an unknown depth between Colon and Bohio, but coming to within 163 ft. below sea level at Bohio and gradually rising to the level of the sea in the vicinity of Gamboa, borings having been made to a depth of 175 ft. below sea level without discovering solid rock, in the vicinity of Gatun. Mr. Nichols' examinations have as yet failed to develop any satisfactory location for a dam in the vicinity of Gatun.

THE TIGER HILL CUT-OFF.—Mr. Nichols is also charged with conducting surveys and examinations to obtain data to enable the Commission to determine the advisability of the construction of what is known as the Tiger Hill Cut-Off, an alternate plan for the location of the axis of the canal between Bohio and Gatun, suggested by the former Isthmian Canal Commission.

The result of Mr. Nichols' examination does not seem to justify changing the location of the canal by the adoption of this cut-off. While the length of the canal would be shortened, it is doubtful whether the advantage obtained thereby would be sufficient to justify the increased cost of construction, particularly when consideration is given to the fact that the amount of rock and other excavation will be largely increased, and that the canal for a portion of the distance would have to be carried across a swamp between two embankments, the success of this construction and the cost thereof being not possible of previous actual determination. The above applies to the 30-ft. level. In case a sea-level canal is decided upon, the cost of the Tiger Hill Cut-Off will be largely increased.

MR. H. F. DOSE, RESIDENT ENGINEER, BOHIO.—The principal object of Mr. Dose's investigations in the vicinity of Bohio is to secure the data necessary to determine the practicability and cost of construction of a high dam in that vicinity. His efforts have been mainly directed toward the detailed examination of two sites which have in the past received the most favorable consideration.

One of these sites is known as Line C, where the cross-section of the valley above the surface of the ground seemed to indicate that it would be a desirable location for a dam, being the point at which a dam could be constructed with minimum expense. The other is Line F, a location farther down the river, which has attracted the attention of the engineers employed by the former Commission on account of the fact that while the cross-section of the valley was larger at this point above the surface of the ground, it was supposed that the depth of foundation would be less, and that on this account Line F would prove the more desirable.

The examinations made under the direction of Mr. Dose have been conducted with extraordinary patience and care; a diamond drill has been used, and sufficient penetration into the underlying strata made to determine definitely the character of the sub-formation. As borings could not be made in the Chagres River during the rainy season, and it was considered necessary to take borings at short intervals, the cross-section showing the complete line of bedrock has not yet been fully determined. It is expected, however, that this work will be completed within the next thirty days, when the matter will be covered by special report.

Sufficient information, however, has been obtained to determine the fact that there is little probability of finding a satisfactory location for a high dam in this vicinity, as the rock gorge in this locality is from 163 to 168 ft. in depth and is filled with an alluvial deposit consisting of clay, gravel, sand and drift wood, the material down to 150 ft. at least being very porous and freely water-bearing.

Of the two locations, however, Line C will prove the more practicable and economical, in case no other more favorable situation can be found. The practicability of using this site for a high dam, and the cost thereof, depend upon the development of a plan to secure the construction of a curtain wall to the bed-rock, which will entirely cut off any possibility of the flow of water through the alluvial formation filling the gorge.

ADDENDA.—Since dictating the above, which is based on Mr. Dose's report of December 31, 1904, Mr. Dose has completed the investigations on Lines C, F and AZ, and has found that the minimum depth to solid rock suitable for a foundation on Line C is 163.6 ft. below sea level; on Line F, 168.3 ft.; and on Line AZ, 142.4 ft.

Line AZ, however, has not been investigated as thoroughly as Lines C and F, because the site is much less favorable than either of the other lines, it being much longer and generally an undesirable location for a dam. It is very probable, however, that if the borings were taken as close together on Line AZ as on Line C, bed-rock would not be found above a depth of 163 ft.

After completing the surveys on the three lines above mentioned, Mr. Dose was directed to investigate thoroughly the line farther up the Chagres Valley, at a point called Buena Vista, between kilometers 25 and 26; and the latest reports from borings at this point show that rock has been found at a depth of 130 ft. below sea level. A line of borings was projected across the valley, commencing at one side. As the borings have proceeded, each new hole has shown the rock at a deeper elevation than the preceding one, indicating a sharp inclination of the bed-rock towards the center of the valley. The probabilities are that the depth of the bed-rock will be located at a much greater depth. At this date the borings are still progressing on the Buena Vista line.

MR. BOYD EHLE, RESIDENT ENGINEER, SAN OBISPO.—Mr. Ehle was charged with the collection of data to determine the possibility and advisability of a dam in the vicinity of Gamboa, and of the construction of a tunnel spillway through the Continental Divide into the Pacific Ocean, or into the headwaters of some stream leading into the Caribbean; also data necessary to solve the incidental problems connected with the construction of a dam at Gamboa, which would be a factor in the building of a sea-level canal or a canal at any elevation up to and including 60 ft. above the sea; particularly should it be decided to devise and adopt any plan of canal with a view to ultimately changing it to a sea-level canal, the construction of a dam at Gamboa in connection with the necessary spillways being a fundamental requisite of a sea level, or of any lock canal not containing the navigable lake feature, and with a summit level under 60 ft.

The essence of the results of Mr. Ehle's investigation is as follows:

1. That the construction of a dam up to the height of 200 ft. at Gamboa is practicable and economical, the bed-rock being found at an elevation of approximately the level of the sea and the configuration of the ground above the sea level giving a cross-section of the valley of moderate and reasonable dimensions at this point.

The situation admits of the construction of a solid core of masonry from the bed-rock to the crest of the dam at an elevation of 200 ft. above sea level, or at whatever elevation may hereafter be determined upon, and the reinforcement of this central core with the broken rock and other debris from Culebra cut.

When it is considered that the distance between the center of gravity at Culebra cut and Gamboa dam is within the limit of the average haul necessary for the disposal of the large amount of material to be removed, the economy of the construction of this dam is apparent.

2. That it is possible to construct a tunnel spillway either through the Continental Divide on to the Pacific slope with a maximum tunnel length of eight miles, or a tunnel spillway onto the Caribbean slope with a maximum tunnel length of 3½ miles.

3. That the approximate area of the reservoir contained by a dam at Gamboa would range from a minimum of 15 sq. miles at a water elevation of 132 ft. above the sea, to a maximum approximate area of 43.3 miles with an elevation of 200 ft.

This in connection with other data obtained by Mr. Ehle clearly demonstrates the fact that the construction of a dam at Gamboa will satisfactorily and economically solve the problem of the control of the Chagres River, the provision of water for any low level lock canal designed, and the supply of sufficient electric energy for lighting purposes, railroad operation, or the operation of machinery used in the construction of the canal; and incidentally a water supply for the towns and villages situated along the line of the canal, and for the supply of the work.

However, the Chief Engineer considers that a more ample allowance should be made for the works outlined above, and would suggest that not less than $5,000,000 be considered the cost of the Gatuncillo tunnel, including the increase in the cross-section of the river diversion between Gatun and the bay east of Colon; and that $12,000,000 be allowed for the Pacific tunnel spillway. He would also suggest that at least $5,000,000 be allowed for the construction of the Gamboa dam and the auxiliary works, not including the power plant. For the provision of electric power plant with all the auxiliaries connected therewith, on the basis of 20,000 HP., he would suggest an estimate of $3,000,000.

This, on the basis of the Gamboa dam being constructed to an elevation of 200 ft., would give estimates as follows:

1. The Gamboa dam, including the Gatuncillo spillway, and enlargement of the Gatun diversion, $10,000,000.
2. The Gamboa dam, including the Pacific spillway, $17,000,000.

Should either one of these plans be adopted, and the establishment of an electric power plant receive consideration, $3,000,000 should be added to the estimate.

While there is no question but that the installation of an electric power plant at this time would be justified, it should not be considered a determining factor in the solution of this problem. As it would require from two to three years to construct the dam and install such a power plant, the work of canal construction would at that time be so far advanced that it is not considered that its installation would cause such saving in the construction, operation and maintenance of the canal as would justify any considerable expense beyond the mere cost of installation of the plant after the construction of the dam with its auxiliary spillways shall have been determined upon.

In other words, the advisability of the construction of the Gamboa dam with its auxiliary works should be de-

termined upon irrespective of the electric energy to be obtained therefrom. This latter question should only be considered in connection with the expenditure necessary for that particular purpose.

MR. CARL A. STROM, MECHANICAL ENGINEER.—On July 5, 1904, Mr. Strom was placed in charge of the Mechanical Department of the Engineering and Construction Department, and he was instructed to immediately examine all the machinery available on the Isthmus and to organize a department for the maintenance and repair of the machinery plant and the machine shops at Cristobal-Colon, Bas Matachin and Empire. This machinery had practically remained idle for over 16 years, and was almost entirely concealed by the jungle, which has been cleared up by Mr. Strom's department and the buildings and machinery repaired and placed in service. While a great deal of this machinery is out of date and will have to be supplemented to some extent by new modern machines, some of it is still available for use. Examinations and experiments are being continually made to determine the amount of equipment found on the Isthmus which can be economically used.

On December 31, Mr. Strom had succeeded in putting into satisfactory operation the shops at Cristobal-Colon, Bas Matachin and Empire, as well as improving the conditions and organization of the smaller repair shops in the vicinity of Culebra.

His organization at the end of December consisted of 465 employes, of whom 51 were master mechanics, clerks, draftsmen, foremen, and high-class mechanics paid in gold, the remaining 414 being mechanics and artisans of various grades of efficiency who had either previously been employed on the Isthmus or in adjacent countries.

The work of rebuilding and repairing excavating machines, engines, and cars, and taking care of other mechanical construction, has been handled by Mr. Strom's department in a satisfactory manner, and the Commission now has at its disposal a mechanical department which is rapidly developing and which will ultimately take care of all the needs and requirements of the work.

MR. M. O. JOHNSON, SUPERVISING ARCHITECT.—On July 19, Mr. M. O. Johnson was installed as Supervising Architect, in charge of planning, estimating and superintending the construction of new structures, and the supervision of repairs, alterations and maintenance of existing structures; also the location of highways and the laying out of grounds adjacent to buildings. Mr. Johnson, under the instructions of the Chief Engineer, has perfected an organization capable of supervising and carrying on the work of his department.

Approximately 2,400 buildings, in various stages of preservation and decay, were found along the line of the canal, all requiring more or less repair, it frequently being impossible to determine from an outward inspection the cost and nature thereof. However, satisfactory progress has been made by the Supervising Architect and the forces under him, and every effort has been made to push this work, in order to provide suitable quarters for the forces employed on the Isthmus.

In this connection it is highly desirable that ground be obtained in the vicinity of Panama for the erection of such buildings as will properly take care of the officers and employes of the Commission stationed in Panama, and their families. As the Commission is aware, our inability to provide properly for the employes at Panama has been due to the delay in securing possession of the necessary real estate at this point. The work of this department has been seriously interferred with by delay in filling requisitions for material and by the inability of the Panama Railroad to furnish prompt and satisfactory transportation facilities.

MR. CARLETON E. DAVIS, ENGINEER WATER-WORKS AND SEWERS.—Mr. Carleton E. Davis arrived on the Isthmus on July 19, 1904, and was placed in charge of the Department of Water-Works and Sewers. He was instructed to give especial attention to the water supply and sewerage systems of Panama, and the general plans thereof have been prepared by his department and approved by the Commission, the work now being under way. A reservoir has been constructed at Rio Grande Superior, and a distributing reservoir at Ancon is under construction. The work of laying outflow sewers in Panama has also commenced.

The Chief Engineer has been notified that the various materials needed for the construction of the water supply and sewerage systems are en route, and organizations have been perfected and preparations made for the prompt prosecution of the work upon the arrival thereof. Recommendations have been made to the Commission in regard to the water supply of Colon, and also as to the paving of the streets of Panama.

The work of this department has also been seriously interfered with by delay in filling requisitions for material and by the inability of the Panama Railroad to furnish prompt and satisfactory transportation facilities.

CAPT. EDWARD L. KING, GENERAL QUARTERMASTER.—Captain King was assigned to duty as General Quartermaster on Aug. 16, 1904, and placed in charge of the selection and assignment to quarters for employes in the Engineering and Construction Department. His office also has charge of all records pertaining to the personnel of the various departments, the supervision of pay-rolls and requisitions, and other similar matters. He also handles all applications for positions and the correspondence connected therewith, as well as all correspondence relating to routine matters affecting his department.

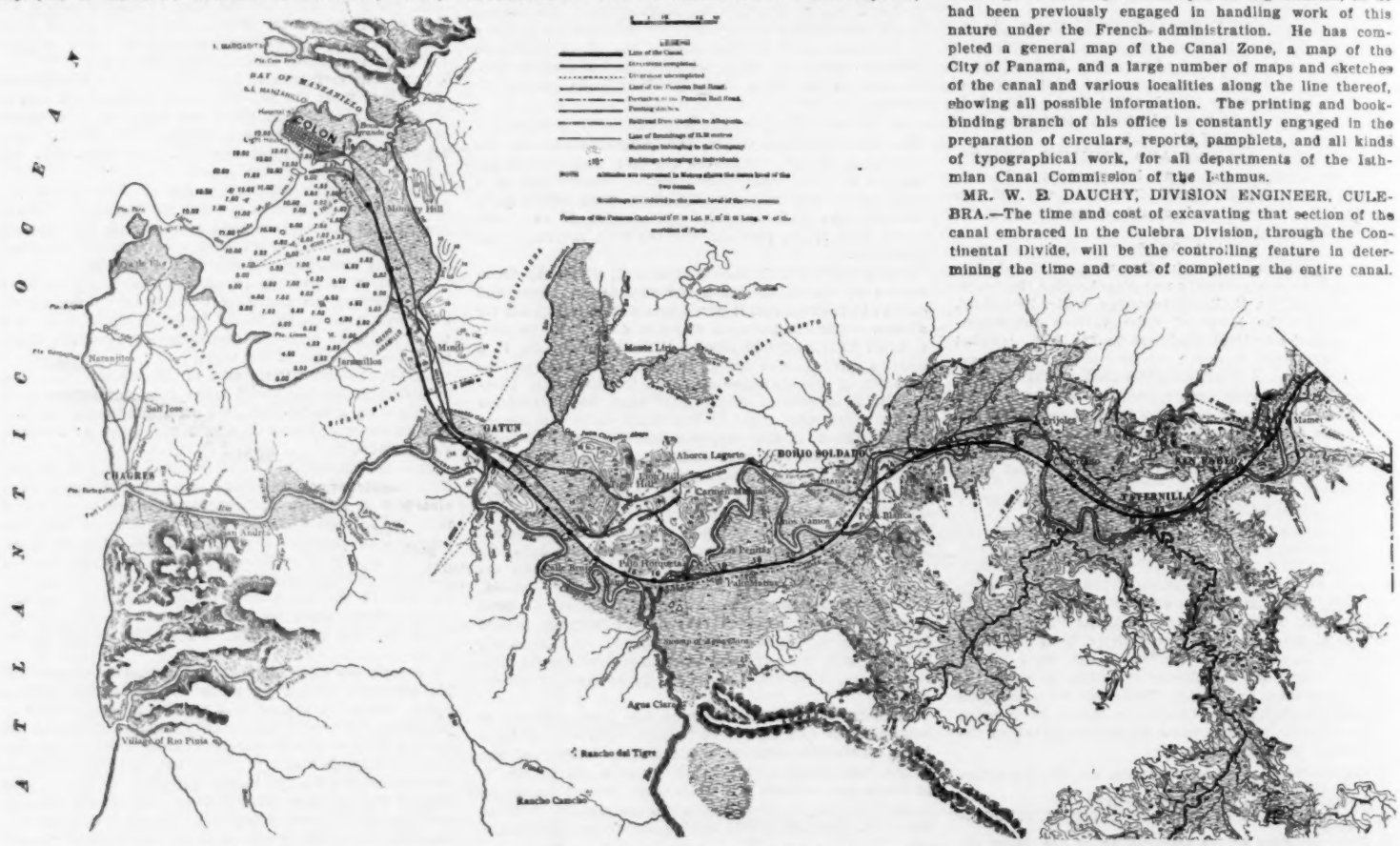
Captain King has perfected a system of checking time and pay-rolls, by which it is possible to have these rolls ready for payment within the minimum time after the date of the pay period, and he is now handling in a very satisfactory manner the rolls for about 3,000 men, representing payments of approximately $40,000 gold and $130,000 silver.

He has also adopted a very complete system of keeping track of individual men employed in this department, the nature of the work done by each, and the manner in which it is performed, so that the efficiency of any employe can be readily ascertained.

The force employed in all departments of the work under the Chief Engineer increased from 2,392 men in July, to 3,620 men in December, this being the total number of men enrolled. However, the average number of men actually at work during July was approximately 1,500 and in December approximately 3,000, the percentage of men at work as compared with the number on the rolls having increased from 63% in July to 83% in December, the practical efficiency of the force having doubled during these six months.

MR. C. BERTONCINI; MAP, LITHOGRAPHING AND PRINTING DEPARTMENT.—Mr. Bertoncini was placed in charge of this department upon its organization, as he had been previously engaged in handling work of this nature under the French administration. He has completed a general map of the Canal Zone, a map of the City of Panama, and a large number of maps and sketches of the canal and various localities along the line thereof, showing all possible information. The printing and bookbinding branch of his office is constantly engaged in the preparation of circulars, reports, pamphlets, and all kinds of typographical work, for all departments of the Isthmian Canal Commission of the Isthmus.

MR. W. E. DAUCHY, DIVISION ENGINEER, CULEBRA.—The time and cost of excavating that section of the canal embraced in the Culebra Division, through the Continental Divide, will be the controlling feature in determining the time and cost of completing the entire canal.



GENERAL MAP OF THE PANAMA CANAL AS PROJECTED BY THE NEW PANAMA CANAL CO. OF FRANCE WITH A SUMMIT LEVEL OF 2,075 METERS.

(Reduced in size one-half from a map accompanying the new book, "Problems of the Panama Canal," by Gen. Henry L. Abbot, Corps of Engineers, U. S. A., credited to "The Engineering Magazine" of February, 1900.)

On May 4, 1904, the French Company turned over this work to Lieutenant Mark Brooke, Corps of Engineers, U. S. A., who had charge of the work at Culebra until May 26, under the direction of Col. W. M. Black, Corps of Engineers, U. S. A. On May 26 Mr. A. C. Harper took charge of the work, reporting to Colonel Black until the Chief Engineer assumed charge, from which time he continued at Culebra as resident engineer until November 20, 1904, on which date Mr. W. E. Dauchy was placed in charge with the title of division engineer, having control over all work on the Culebra Division, including engineering, construction and mechanical, his jurisdiction extending over such territory as might be necessary not only for the excavation but for the disposal of material removed, reporting to the Chief Engineer.

During the last six months the work at Culebra has been steadily prosecuted, the principal object being to determine the efficiency of the men and machines engaged in the work and to obtain reliable units as to capacity, time and cost, upon which to base future estimates for the completion of the work on this central division. Care has been taken to experiment sufficiently with the different

classes of material and the different machinery available to determine these elements of time and cost.

The operations to December 31 have practically been conducted with the force and machinery formerly used by the French, it being very desirable to know for comparative purposes later on what could be done with the French machinery and with the character of labor available.

This experimental work has determined, at least to the satisfaction of the Chief Engineer, that the work of excavation and removal of material from the Culebra cut can be performed on an average of not to exceed 50 cts. per cu. yd. The average results for the eight months ending December 31, 1904, have been 54.7 cts., but during November and December the average cost was 50.1 cts.

The amount of monthly output has increased from 27,556 cu. yds. in May to 42,935 cu. yds. in December, the total amount of material excavated and disposed of from May 4 to December 31, 1904, being 243,472 cu. yds.

Since the preceding paragraphs were written the results of the operations for the month of January show that 70,650 cu. yds. were excavated during that month, at an average cost of 46.8 cts. This latter amount also includes an arbitrary charge of 5 cts. per yard to cover the installation of modern American machinery, which will be rapidly installed from this time on, and the cost of which should be spread over and absorbed by the entire work. This arbitrary charge of 5 cts. per cu. yd. is estimated to be amply sufficient to cover the entire cost of installation of all tracks, machinery and appliances necessary for the excavation of Culebra cut.

During this period contracts have been let for the construction and delivery of 14 modern American steam shovels and 200 American steel flat cars, with various mechanical appliances for the unloading and spreading of the material on the spoil banks. Up to December 31 three steam shovels had arrived and been delivered on the work, two of which had been erected and were doing experimental service at the close of the year.

During this eight months period the number of laborers employed on the Culebra Division varied from a maximum of 669 in June to a minimum of 384 in October. During December the average number was 543 men, being only 10 more than the number employed in May, which was 553. This comparative statement is applied to common labor alone, and shows the necessity for immediate radical measures to increase the number of laborers.

The increase in labor employed on the entire work during this period has been absorbed in the mechanical and building trades, in the construction of water supply and sewerage systems, and in the Sanitary Department, these departments being more attractive to the laborer than the work in the Culebra excavation.

The average cost of excavation at Culebra cut for the eight months from May to December, inclusive, during which time 243,472 cu. yds. of material were excavated and disposed of, was as follows:

Installation of plant	1.5 cts.
Mining	11.2 "
Loading material	11.0 "
Transportation to dumps	11.5 "
Dumps	4.5 "
Maintenance of track	8.4 "
General expenses	6.6 "
Average cost per cu. yd.	54.7 cts.

The average cost per month for the six months from July to December, inclusive, was as follows:

July	65.4 cts.
August	50.6 "
September	57.3 "
October	54.1 "
November	50.1 "
December	50.1 "

December 31 practically closed the period of experimentation with the French machinery and appliances. During this period close attention has been given to every detail of the work. The character of the men employed, and the various conditions surrounding it, have been carefully considered, and the nucleus of an organization for future work has been gradually formed.

Jan. 1, 1905, may be considered as the commencement of the work with the use of American machinery and organization.

The results for the month of January show, as above-stated, the excavation of 70,650 cu. yds., at the following costs:

Arbitrary for plant	5.0 cts.
Mining	11.0 "
Loading	7.9 "
Transportation to dumps	9.2 "
Dumps	4.1 "
Maintenance of track	6.1 "
General expenses	3.5 "
Average cost per cu. yd.	46.8 cts.

The character of the material excavated consisted of solid rock, soft rock and earth, in the approximate proportion in which these various classes of material exist in the excavation.

Since the preceding paragraphs in regard to force were dictated, the efforts made by the Chief Engineer to obtain laborers from the surrounding country have resulted in the increase of the force employed at Culebra to 1,142.

GENERAL COMMENT.—Careful consideration of the results of the technical studies, observations and experimental work has led to the following conclusions:

That the key of the entire canal problem is the excavation and removal of material in what is known as the Culebra Division, this being approximately 7½ miles in length on the basis of the summit level of the canal being 90 ft. above the sea, and 10 to 14 miles in length for summit levels at lower elevations.

While it is true that the actual excavation will extend on the 60-ft. level, 30-ft. level, and sea-level plans, to a greater distance, 14 miles will practically be the extent of the Culebra excavation, as beyond this limit the character of the work changes to such a degree as to admit of different methods of treatment as compared with the excavation of the Culebra Division.

In regard to the Culebra Division the following conclusions have been reached:

(1) That the completion of this division is the controlling feature of the entire work, in both time and cost.

(2) That the controlling factor as to time is the number of excavating units which can be installed, operated and properly served with transportation facilities.

(3) That the controlling element as to time and cost lies primarily in the exercise of constant, intelligent and vigorous executive control over the work at all times; and, secondarily, in the maintenance of proper relations between the various factors and facilities necessary for the conduct of the work as a whole.

The operation of the various units of excavation should be efficient and continuous.

To this end mining and blasting operations should be conducted in a prompt and intelligent manner, so that the material may be properly prepared for the work of the excavators.

Sufficient cars should be provided and properly handled, so that under no possible contingency should it be necessary for an excavating machine to be idle waiting for cars.

Repair parts of the various machines should be kept conveniently at hand, and an efficient repair force provided, in order that no delays may occur by reason of the breakage of any part of an excavating machine.

Sufficient tracks, properly arranged, should be provided, so that cars can be fed to each excavating machine as a continuous operation, without requiring trains of loaded cars to be switched in order to permit the passage of trains of empty cars coming to the shovel from the same direction.

Sufficient engines should be provided to secure the prompt and efficient handling of the loaded cars and the return of the empties to the shovel.

Unloading facilities, dump cars, and other appliances should be provided to further assist toward this end.

The dumps should be of such number and so arranged as to permit of the continuous progress of the work during both wet and dry seasons.

A large number of spoil banks are necessary in order that alternate dumps can be used in case of settlement of banks.

The personnel of the supervisory force should be carefully studied and considered, and should not only be of proper capacity but sufficient in number so that no delays will result through sickness, leave of absence or depletion from other causes.

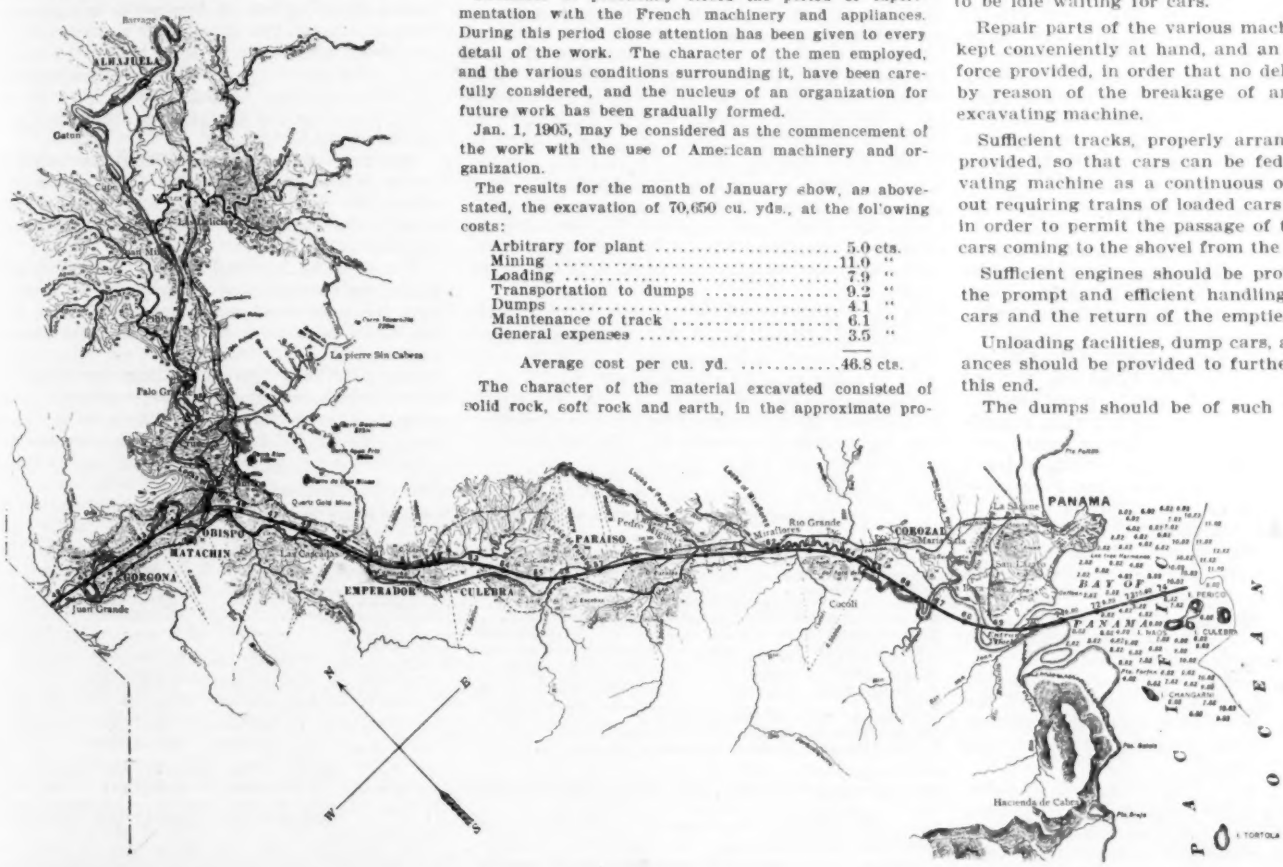
COST.—From the observations of the Chief Engineer he is satisfied that 50 cts. per cu. yd. on the average for all classes of material is a safe and conservative unit price to apply to the excavation of material from this central section.

A mere perfunctory management of the work might increase this cost to 60 cts., and inefficient control increase it still further.

On the other hand, it is possible that, with efficient management, the use of the best machinery, the watching of every detail, and the inspiring of individual members of the organization with the zeal of emulation, the cost may be reduced to 40 cts. per cu. yd., or even lower.

However, under the existing conditions the Chief Engineer feels warranted in recommending 50 cts. per cu. yd. as the unit price for this central section, for estimating purposes.

CAPACITY FOR EXCAVATION.—He is also satisfied that each excavating unit, after the necessary track systems are properly installed and the organization perfected, will produce an average output of 1,000 cu. yds. per machine per single daily shift; and that this average can be continu-



ously maintained, yielding an output of 300,000 yds. per annum per machine.

It is possible to work three shovels on each mile of distance on each of three levels simultaneously on each side of the center line of excavation. This will make a maximum number in actual operation of 144 excavating machines as a possible installation in 8 miles.

As it will require, however, at least two years for the installation of a plant of this character, and allowance for accident and delay during the progress of the work should be considered, it would not be wise to make calculations on an excess of 100 machines continuously at work.

This would yield an output of 30,000,000 yards per annum.

TIME.—On the sea-level plan there are, in round numbers, 186,000,000 cu. yds. of material in the Culebra Division, which would require on the above basis six years to excavate. Allowing two years for preparation and two years in addition for contingencies and unforeseen delays, it would seem evident that it would be possible to complete the canal or at least open it for use in ten years, certainly in twelve.

It should be borne in mind that this computation is based on single shifts only for each 24 hours, and the stoppage of the work on Sundays and legal holidays. The work could of course be still further expedited, at least sufficiently to compensate for extraordinary contingencies, by double shifts and continuous work.

On the 30-ft. level plan there are in the Culebra Division approximately 142,000,000 cu. yds. of material to be removed, which would require about five years. Allowing two years for organization and the installation of the necessary machinery to give the full average output, and one year for contingencies, the work could be completed in eight years, or at least in ten.

A canal on the 60-ft. level will require the removal of 111,000,000 cu. yds. of material from Culebra, which upon the above calculations should be accomplished in seven years, or at least in eight.

The Chief Engineer believes these estimates as to time to be liberal and conservative.

It may be considered as a fundamental fact that all work connected with the construction of the canal can easily be completed and in operation within the time required for the completion of the central Culebra Division.

THE GAMBOA DAM.—Suitable rock foundation for a high dam has been found at Gamboa, and locations for tunnel spillways have been secured which will permit the reservoir formed by this dam to discharge either on to the Pacific or Caribbean slope.

It has been demonstrated beyond reasonble doubt that the Chagres River can be satisfactorily and safely controlled by a work of this character, which does not present any engineering problems that have not been already satisfactorily and repeatedly solved in various parts of the civilized world.

Investigations in the Chagres Valley have practically demonstrated the existence of a deep gorge, with solid rock formation surrounding it, extending from the Caribbean Seat at unknown depth but having a depth of 165 ft. below the level of the sea in the vicinity of Bohio and rising to sea level at Gamboa.

At Bohio the bed-rock forming the original gorge of the Chagres has been fully and carefully developed on three separate sections, and the valley has been found filled with alluvial deposits consisting of boulders, gravel, sand, clay and drift wood.

The formation of the valley in this locality would indicate the necessity of the construction of a core wall, or curtain, to at least 150 ft. below sea level.

While the problems connected with this dam are capable of satisfactory solution, and it is within the limits of practicability to construct a safe and satisfactory dam foundation at this point, the location at Gamboa is much more satisfactory, and, other things being equal, the latter site is preferred.

Examinations in the vicinity of Tiger Hill and Gatun have demonstrated that the formation in the Chagres Valley is such that it would be impracticable and inadvisable to attempt the construction of a dam, even at moderate height, in this locality.

The experimental work in the Culebra excavation has demonstrated that a large saving can be made in the excavation of material at this point as compared with former estimates.

It may be considered as a fundamental proposition that a canal should be constructed with the lowest possible summit level, and with the least number of locks and dams and auxiliary works. There seems to be no reason, therefore, why a canal should be constructed with a summit level exceeding 50 or 60 ft.

Granted that this elevation is not only possible but desirable, the possibility of the ultimate reduction of this height should be considered.

It is evident that the construction of a dam at Bohio and the creation of an artificial lake will introduce an element into the problem which would render any future reduction of the summit level impracticable, considering the time and cost and the possibility of the canal being closed to traffic for a number of years during the process.

It therefore seems that the construction of a dam at Gamboa is the logical solution of the question, this dam being capable of performing its functions regardless of any changes which hereafter may be made in the form or level of the canal.

A dam at this point would control the Chagres River and furnish water for whatever summit level may hereafter be adopted, and also be available as a source of water and power supply.

Comparing the scheme of a dam at Gamboa with one at Bohio, it should be borne in mind that the destruction of a dam at Bohio by the forces of nature or by the act of man in time of war or otherwise, would close the canal absolutely to traffic until such time as it was repaired.

The destruction or failure of a dam at Gamboa would at most only cause a temporary interruption of the traffic of the canal, and the interference with navigation would extend over a comparatively short period compared with the interference due to the destruction of a dam at Bohio and the use of the lake formed by such dam for purposes of navigation.

PLAN OF CANAL.—It therefore seems safe and conservative to say that the summit level should not exceed 60 ft. in height.

While it is true that work can continue for some length of time at Culebra without the elevation of the summit level of the canal being absolutely determined upon at this time, still it would materially assist in the conduct of the work if this level could be decided, at least approximately.

It is so self-evidently true that a sea-level canal is the most desirable in economy of maintenance, operation, time of passage through it, and simplicity of design, plan and execution, that as a problem, "per se," it is the only solution, the deterrent factors being time and cost.

Comparing a plan providing for an approximate elevation of 30 ft. above sea level with a plan providing for a 90-ft. level, it should be remembered that a 30-ft. summit level canal will cause the elimination of four expensive locks, and of a dam expensive and difficult of construction, and the substitution of a dam that could be easily, expeditiously and economically constructed.

Comparing the 30-ft. level with the 60-ft. level two expensive locks are eliminated, and the summit reduced to an elevation which would materially simplify the problem of a still further reduction, should the construction of a sea-level canal hereafter be deemed advisable.

Comparing this plan with a sea-level plan, it should be borne in mind that even with a sea-level canal at least one lock will be necessary in the vicinity of Miraflores. Therefore, only one additional lock will be required over and above that necessary for a sea-level canal. There will be no question as to the provision of an ample supply of water for the summit level as provided by the Gamboa dam.

Should a sea-level canal be determined upon during the progress of the work, comparatively little expense will be entailed by a change of plan provided that change is made before the completion of the summit cut and before it is necessary to commence work on the locks in order to have them ready for use by the time the central excavation is completed.

On the basis of a canal 150 ft. in width, the slopes in the summit section for a canal 30 ft. above the sea, carried down to the necessary depth for a sea-level canal, would only narrow the channel to 120 ft.

It would be a comparatively easy matter to widen the summit excavation to the width necessary for a sea-level canal, provided it was found advisable to make a change during the progress of the work.

ESTIMATES.—The Chief Engineer would respectfully submit the following comparative estimates, showing the cost of the canal in accordance with the different plans previously discussed:

ISTHMIAN CANAL ESTIMATES.—SUMMARY.

Canal Prism Based on a Width of 150 Feet at Bottom and Minimum Depth of Water of 35 Feet.

ITEMS	Sea Level	30 ft. Level	60 ft. Level
Breakwater, Colon	$5,000,000	$5,000,000	$5,000,000
Colon, Inner Harbor	8,373,000	8,373,000	8,373,000
Direct Entrance	1,500,000	1,500,000	1,500,000
Harbor to Bohio, including Levees	11,099,839	11,099,839	11,099,839
Bohio Locks and Spillway (including excavation)	.....	7,000,000	9,000,000
Bohio Dam and Spillway	.....	.....	5,000,000
Pedro Miguel Lock	.....	.....	6,000,000
Excavation, Bohio to Miraflores	125,000,000	86,000,000	59,500,000
Retaining Walls, Culebra Cut	10,394,794	10,394,794	10,394,794
Miraflores Lock	4,000,000	5,781,401	5,781,401
Pacific Level	12,427,971	12,427,971	12,427,971
Chagres and Gatun Diversions	3,000,000	3,000,000	3,000,000
Panama Railroad Diversion	1,267,500	1,267,500	1,267,500
Gamboa Dam and Spillway	10,000,000	10,000,000	10,000,000
Total	$192,063,104	$161,844,505	$148,344,505
Add 20% for Administration, Engineering, Sanitation and Contingencies	38,412,621	32,368,901	29,668,901
Grand Total	$230,475,725	$194,213,406	$178,013,406

February 13, 1905

The above estimate is based primarily upon the unit prices adopted by the former Isthmian Canal Commission, as contained in its official reports, modified, however, by the results of the actual experimental work conducted under the personal direction and observation of the Chief Engineer. The quantities and unit prices are considered sufficient.

RECOMMENDATIONS.—The Chief Engineer therefore recommends to the favorable consideration of the Commission:

1. That harbor facilities be at once provided in the vicinity of Colon. (a) By the construction of an inner harbor at Cristobal-Colon along the general lines of the report previously submitted by the Chief Engineer and as modified by conference with the Engineering Committee. (b) By the construction of a breakwater at least 4,000 ft. long, to protect the east side of the outer harbor of Colon.

2. That the work of completing the Gatun Diversion be proceeded with at once.

3. That the location of a dam with the crest approximately 2,200 ft. above sea level, be decided upon at Gamboa; and that the work of construction be organized and commenced as soon as the plans for such structure have been approved by the Commission.

4. Considering the fact that the Panama canal is intended to serve the commerce of the world through centuries yet to come; that it is not a commercial enterprise to be carried forward for the immediate benefit of the present generation; that the American nation has voluntarily undertaken this great work, and that the question of

merely a few years of time or a few millions of dollars of cost more or less, should not be controlling factors, it would seem proper to treat the problem from a broad and liberal standpoint.

Therefore, it is recommended that no temporary or tentative plan be adopted that will interfere with the final adoption of the "Sea Level Plan," which it is hoped will ultimately receive the favorable consideration of the Commission.

CONCLUSION.—In conclusion, it is considered that if the above recommendations, either with or without modifications, are acted upon and approved, it will remove the principal elements of uncertainty now existing in regard to the project as a whole, and will materially expedite the future progress of the work.

Very respectfully,

John F. Wallace,
Chief Engineer.

Panama, Feb. 1, 1905.

MUNICIPAL STREET RAILWAYS IN CHICAGO.

The municipal ownership of street railways in Chicago is now being actively promoted in two different and independent directions. The larger project is for the acquisition by the city of the entire street railway system now owned and operated by the local companies, as noted in our issue of April 13. To this project the new mayor, Mr. Dunne, proposes to devote his main energies. The other project, which was mentioned in our issue of April 6, and which promises more immediate fulfilment, is the establishment of a municipal street railway system composed of lines (mainly on the West Side) in streets where the rights of the present occupants (the Chicago Passenger Ry. Co.) have expired or will expire during 1905 and 1906; also such other streets as the City Council may deem advisable for making connected lines and routes. The system will first include the following lines: Adams St. from Clark St. to Desplaines St., to Harrison St., to Western Ave., to 12th St., and to Crawford Ave. Also on Halsted St. from Harrison St. south to the Chicago River, and on Ogden Ave. from Harrison St. to 40th Ave. Possession of these streets will not be given by the city until after the decision by the U. S. Circuit Court in the pending injunction suit which involves the date of expiration of the ordinance rights of the Chicago Passenger Ry. Co., nor until the date determined by the final decree in this case. Bids for "the construction and installation" of this system are now called for and will be opened on July 1, 1905. The city has appointed Mr. Bion J. Arnold, M. Am. Inst. Elec. Engr., as consulting engineer to prepare plans and specifications for this system; his terms provide for a payment of 1½% of the total cost for the preliminary work, 1½% for preparing the detail plans and specifications if the project is carried out, and 2% for supervision of the work.

This step is of such importance, and is being watched with such interest by other cities that we give below some extracts from the advertisement for bids:

Payments by the city shall be made either by the delivery of street railway certificates to be issued under an act of the general assembly of Illinois, entitled "An act to authorize cities to acquire, construct, own, operate, and lease street railways, and to provide the means therefor," commonly known as the Mueller law, or in cash from the proceeds of the sale of such street railway certificates by the city.

Bids shall be separately submitted for the construction of tracks upon the streets specifically named and for the installation thereon of all the necessary equipment for the operation of street railways. Said bids shall be submitted on the basis of a unit price per mile of track with overhead contact wire equipment, and a unit price per mile of track with underground electric conduit equipment; the construction in either case to be in accordance with the recommendations regarding such classes of construction in the "Report on the Chicago Transportation Problem," by Bion J. Arnold, 1902; the purpose being that the city council shall hereafter determine what part of the system shall be equipped with underground and what part with overhead appliances for electric propulsion, and reserves the right to itself furnish and distribute electric power to the system.

Separate bids shall also be submitted for the construction and equipment of the necessary power house and distribution system and in accordance with plans and specifications to be furnished by the city.

Separate bids shall also be submitted for the furnishing of not less than 50 nor more than 350 cars of the double-truck type, and not less than 40 ft. in length over all, cross reversible back seats, center aisle, equipped with four 30-HP. motors, air brakes, fenders, sand boxes, and other devices for the safety and convenience of the traveling public. Separate bids shall be submitted for snow plows, sweepers, repair cars, and work cars.

Detailed plans and specifications with regard to all matters hereinabove referred to will be prepared by the city of Chicago and can be obtained from the Commissioner of Public Works on or after June 1, 1905.

If bids are submitted upon the basis of payments by means of the delivery of street railway certificates secured in accordance with the provisions of the Mueller law, such bids may be separately submitted on the basis that the city shall, itself, operate said system or systems by its own employes, or that the city will lease such system or systems to the highest and best bidder, at least half of the rental thus obtained to constitute a trust fund to provide additional security for the payment of the certificates and the interest thereon.

Bids may be submitted upon the basis that the completed system when equipped and installed shall be so leased to such bidder, and in such case he shall submit with his bid the percentage of the gross receipts of the system, or the amount of cash per year and the term of years (not to exceed 20), which shall be provided for in such lease, and in such case the person bidding the highest percentage of gross receipts, other things being equal, shall be considered the best bidder. In case of bids based upon percentages of gross receipts, other things being equal, the bidder who shall accept the lease for the shortest period of time shall be considered the best bidder. If proposals shall be submitted upon the basis of the lease of the system to the bidder, as provided for above, the lease shall be prepared by the authority of the city council and shall contain, among other things, the following provisions, in addition to those already expressed:

(1) That the operation of cars upon the whole of said system shall at all times be subject to the reasonable exercise of the police power of the city.

(2) That the rate of fare upon said system shall be 5 cts. for adults and 3 cts. for children between the ages of 7 and 12 years, children under 7 years of age, if accompanied by an adult, shall be carried free.

(3) That the lessee and operator of said system shall exchange transfers with any other company in the city whose lines cross or come within a distance of 200 ft. of the lines of said lessee and operator.

(4) The city shall have the right to commute its compensation by the reduction of fares; provided, however, that such reduction of fares shall never be so exercised as to impair the accumulation of a trust fund for the payment of said street railway certificates at maturity, and interest thereon as the same accrues.

Bids may also be submitted for the privilege of constructing and operating street railway tracks and a system of cars in the various streets referred to, and such other streets as the city may lawfully designate from time to time, and in such case the bidder who agrees to pay for such privilege the highest percentage of the gross receipts to be received from such operation for the shortest term, shall, other things being equal, be considered the highest bidder. In such case the bidder may specify the streets and parts of streets upon which he desires to bid.

Proposals are also invited by the city for the sale to the city of existing tracks, wires and equipment owned or claimed to be owned by the companies whose ordinance-rights in the streets above mentioned or in any part thereof have expired.

NOTES FROM THE ENGINEERING SCHOOLS.

THE STEVENS INSTITUTE OF TECHNOLOGY.—The institute has for many years followed the plan of calling in practising engineers from time to time to address the student-body on special topics. After the members of the senior class have passed their final examinations, about six weeks of the school year will remain, during which they will not be subject to the routine of the regular roster. This time is assigned mainly to the preparation of theses but four hours per week will be reserved for a course of special lectures, to be delivered by a number of professional men, eminent in their several lines of work. This schedule is expected to include talks on telephone practice, ship propulsion, the business features of engineering practice, patent law, civil engineering, electrical engineering, the advantages of system, etc. The final lecture will be delivered by President Alex. C. Humphreys.

GEOLOGICAL FIELD WORK.—Twenty-eight leading universities and colleges announce that, under certain conditions, credit will be given to any of their students who will take any of the nineteen Summer courses in Geology that are offered by nine different institutions.

In the Appalachian course of five weeks, July 3-Aug. 5, the instructors are Profs. W. B. Clark, of Johns Hopkins University, on the tertiary and cretaceous strata of the coastal plain of Maryland; W. M. Davis, of Harvard, on the folded palaeozoic strata of the Susquehanna-Juniata district of Pennsylvania; T. C. Hopkins, of Syracuse, on the horizontal palaeozoic strata and glacial features of Central New York; H. P. Cushing, of Western Reserve, on the faulted crystalline and palaeozoic rocks of the Little Falls district, N. Y., and J. Barrell, of Yale, on the metamorphic and triassic rocks of Western Connecticut.

This course is only for men who have some knowledge of general geology; the fee is $20, or for each week separately $5.

Harvard offers three courses in Montana, the Rocky Mountains, and Iceland; the University of Chicago, five; Leland Stanford, two; one in the Santa Crux Mountains, and the other in the Mount Hamilton range; and the Universities of Wisconsin, Kansas, North Carolina, Johns Hopkins, and Columbia one each, in the states in which they are situated. Full information may be obtained from the head of the department of geology in each institution.

ELECTRIC GENERATING UNITS OF 10,000 KW. normal capacity are proposed for a central electric station which a new company desires to erect in London, England. This concern, The Administrative County of London & District Electric Power Co., is now applying to Parliament for authorization to construct a generating and distributing system and supply electricity to the public within the County of London and certain adjacent districts. Three generating stations are planned for, and these are intended to produce power cheaply by using steam turbine generating sets each of 10,000 kw. normal capacity, and 100% overload capacity (maximum capacity for a short period, 20,000 kw. or 27,000 h. p.) The promoters expect to generate electricity at an operating cost of 0.154d. per kilowatt-hour, and sell it at a rate not exceeding 1½d. per kilowatt-hour, or (on the consumer's demand) at a fixed price not exceeding £1 per quarter per kilowatt maximum demand, plus a charge not exceeding ½d. per kilowatt-hour used. This would enable consumers to buy electric power at a rate less than 2 cts. per kilowatt-hour even in small amounts. The company intends to do principally a power business; a line pressure (underground distribution) of 12,000 volts at 25 cycles, is proposed. The probable cost of the generating stations, based on 90,000 kw. capacity, will it is said be less than £10 (about $50) per kilowatt.

A GASOLINE LOCOMOTIVE for mining work has recently been built for the Britannia Copper Mining Co., of Vancouver, B. C. A 35-HP. vertical four-cylinder engine, as used in automobiles, drives a shaft with gearing for two speeds (2 and 5 miles an hour) either forward or backward. A bevel pinion on the transmission shaft meshes with two bevel spur wheels, each carrying a friction clutch, through which passes a 3-in. shaft. From this shaft one of the axles is driven by a chain. The ignition is on the jump spark system, and the exhaust gases are discharged into a water tank to absorb the odor and deaden the sound. The machine weighs about 8 tons, and can haul a 60-ton train at 5 miles an hour. It was built by the Charles Kaestner Mfg. Co., of South Bend, Ind.

A GASOLINE-ELECTRIC MOTOR CAR for baggage and express service on the line of the St. Joseph Valley Traction Co. has recently been built, but the engine room occupies about two-thirds of the length. The car is 34 ft. long, mounted on two four-wheel trucks with a 35-HP. motor to each axle. Current is supplied by a 50-KW., 250-volt generator, directly connected to a four-cylinder marine gas engine of 70-HP. There is a battery of 120 chloride accumulators to relieve the generator of the heavy load in starting; the battery also furnishes current to drive the generator as a motor to start the gas engine. There is also an air compressor supplying air at 200 lbs. pressure from a storage tank for this game purpose. The total weight is 86,650 lbs.; of this amount the body and trucks represent 33,600 lbs.; the motors, 19,000 lbs.; and the gas engine, generator and battery, 33,250 lbs. The car was built by the Hicks Locomotive & Car Works, Chicago.

DEEP FOUNDATIONS IN FROZEN GROUND have been constructed on the Trans-Siberian Railway in a number of cases where otherwise difficult sheeting or cofferdam work would have been required. In one case a bridge pier was founded in an open excavation made in winter when the river was frozen solid to the bottom, the temperature being about 15° F. Another pier and two abutments were founded in the same manner, the pier excavation going to a depth of 42 ft. below mean water level. In such work it is necessary to keep close watch over the thickness of frozen material around the pit, and to stop work as often as may be required to allow the walls and bottom to freeze to greater depth. Blowing outside air into the ground by a bellows or blower arrangement was found expeditious at times. On some stretches the railway passes through country where the ground is frozen all the year round, at the surface and to a variable, generally indeterminate depth. Excavation in such ground, if deep, must guard against penetrating the frozen depth and reaching the warmer and water-bearing layers. In general, excavation in frozen ground has proven to be fairly expensive, though the expense of sheeting or pumping is, of course, avoided. The subsequent masonry work must be carried on in heated enclosures, and its cost is nearly twice as great as masonry work in summer.

PERSONAL.

Mr. John A. Jones has been reelected City Engineer of Lewiston, Me.

Mr. Robert Hooke has been reappointed City Engineer of Chattanooga, Tenn.

Mr. Lee L. Harper, formerly City Engineer of East St. Louis, Ill., has been appointed City Engineer of Belleville, Ill.

Mr. H. S. Rogers has been appointed Chief Engineer of the Manistee & Grand Rapids R. R., succeeding A. Fronhoefer.

Mr. Herbert A. Holstein, Assistant City Engineer of Dunkirk, N. Y., has been appointed Civil Engineer for Tituasville, N. Y.

Mr. E. G. Tilton, heretofore Acting Chief Engineer of the San Pedro, Los Angeles & Salt Lake R. R. has been appointed Chief Engineer.

Mr. G. H. McDonough has been appointed Signal Engineer of the entire system of the Cleveland, Cincinnati, Chicago & St. Louis R. R.

Mr. J. K. Sroufe has been appointed Engineer Maintenance of Way of the Toledo, St. Louis & Western R. R., with headquarters at Frankford, Ind.

Mr. H. R. Safford, Assistant Chief Engineer of the Illinois Central R. R. has been appointed Assistant Chief Engineer of the Yazoo & Mississippi Valley R. R.

Mr. H. Pierce has been appointed Engineer of Construction of the Chesapeake & Ohio Ry., with headquarters at Richmond, Va., succeeding Mr. F. I. Cabell, transferred.

Mr. B. J. Arnold, M. Am. Inst. El. E., has been appointed consulting engineer for the city of Chicago in connection with the proposed system of municipal street railways.

Mr. E. B. Ellicott, who has been City Electrician of Chicago, Ill., for several years, has been appointed Assistant Engineer of the Chicago Sanitary District, in special charge of the water-power development work.

Mr. B. J. Dalton has resigned as City Engineer of Lawrence, Kan., to accept a position in railroad work. Mr. E. E. Trueblood will complete Mr. Dalton's term of office as City Engineer.

Mr. S. S. Roberts, heretofore Roadmaster of the Louisville & Nashville R. R., at Elizabethtown, Ky., has been appointed Assistant Engineer and Roadmaster of the terminal of the above road at Louisville, Ky.

Mr. Lewis H. Harper has left the employ of the U. S. Coal & Coke Co., at Gary, W. Va., and has accepted a position with the Central of Georgia Ry. on a locating party, with headquarters for the present at Greenville ,Ga.

Mr. C. B. Scott, Assoc. M. Am. Soc. C. E., has resigned his position as Engineer of the Beacon Coal & Coke Co., Davis, W. Va., and has accepted a position as Resident Engineer on the Chesapeake & Ohio Ry., at Lawson, W. Va.

Mr. Fred Crandell, City Civil Engineer of Muncie, Ind., since January, 1903, has resigned that position. He has accepted a position in the Engineering Department of the Great Northern R. R., and will be located in Spokane, Wash.

Mr. J. H. Conely, formerly with the J. S. Paterson Construction Co., as superintendent on the concrete viaduct approaches of the Thebes Bridge, is now with Mr. D. D. Streeter as superintendent of the concrete work for the New York Central Ry. at Schenectady, N. Y.

Mr. C. C. Conkling, M. Am. Soc. C. E., has resigned as Chief Civil Engineer of the Lackawanna Steel Co., and the South Buffalo Ry. Co. He will, however, remain with the companies as cousulting engineer, and will open an office in Buffalo, N. Y., for the practice of his profession.

Mr. W. W. Crosby has been elected Chief Engineer in the Division of Highways of the Maryland Geological Survey, to succeed Mr. A. N. Johnson, Assoc. M. Am. Soc. C. E., whose recent resignation to accept the position of Highway Engineer of the U. S. Office of Public Roads, was mentioned in this column last week.

Capts. Charles Keller and Spencer Crosby, First Lieutenants Edward M. Adams, Hubert L. Wigmore, William P. Stokey, John H. Poole and Henry C. Jewett, of the Corps of Engineers, have been relieved from duty in the Philippines and ordered to proceed with Companies I and K, 3d Battalion of Engineers, to San Francisco on the transport to sail from Manila about July 15.

Mr. Elver L. Shinbur, of Nebraska, has been appointed an Assistant Engineer in the U. S. Reclamation Service, and has been ordered to report to Mr. M. C. Hinderbider, Engineer in Charge of the La Plata Project in New Mexico. The above is a correction of the item in a previous issue stating that Mr. Shinbur had been appointed an Engineering Aid in the U. S. Reclamation Service.

Mr. W. H. Kennedy, M. Am. Soc. C. E., owing to ill health has resigned his position as Chief Engineer of the Oregon Railroad & Navigation Co. Mr. G. W. Boschke, formerly Assistant Engineer of the Southern Parific Ry., at San Francisco, succeeds him. Mr. Kennedy came to the Pacific coast in 1880, and most of the time since then he has been Chief Engineer of the above mentioned railroad.

Mr. Walter C. Wilson has been appointed Engineering Aid in the U. S. Reclamation Service and left Washington April 11 for Minidoka, Idaho, to report to F. C. Horn, Constructing Engineer. Mr. Wilson, who is a native of Indiana, attended Earlham College at Richmond, that state, and is a graduate student of Sheffield Scientific School, Yale University. He has been engaged in surveying for the Pennsylvania R. R. Co., and as draftsman for the Louisiana Purchase Exposition.

Mr. H. M. Morse, Engineering Aid in U. S. Reclamation Service, has been transferred to Montana, where he will be engaged upon hydrographic work on the Milk River project under the supervision of Mr. C. C. Babb. Mr. Morse was graduated from Dartmouth college with the degrees of B. S., and from the Thayer School of Civil Engineering with the degree of C.E. He has served in the capacity of Assistant Engineer on the water-works at Needham, Falmouth, and Lexington, Mass.

Obituary.

Henry L. Fry, Engineer Maintenance of Way of the Southern R. R., at Greensboro, N. C., died April 8, aged 54.

Hermann Steinmann, an architect, making a specialty of designing breweries, committed suicide April 12 in his office at 66 New St., New York City by asphyxiation.

Ralph G. Young, Instructor in Sibley College of Mechanical Engineering, Cornell University, died, April 12, of pneumonia. He was a graduate of Cornell University, in the class of 1901.

James C. Todd, of the firm of Todd, Mackay & Co., manufacturers of hemp and flax machinery, died April 17, at his home in Paterson, N. J. Mr. Todd came to Paterson in 1826, and is said to have worked on the construction of the first locomotive turned out by the Rogers Machine Works in 1837.

William S. Snedes, a civil engineer of Red Bank, N. J., died in that place, April 14, of pneumonia. Mr. Snedes made surveys for the Erie R. R., the Northern Central, the Northern New Jersey, the New Jersey Southern, the New York & Long Branch, and the Jacksonville, Tampa & Key West. He was largely instrumental in establishing Red Bank's water system. He was 76 years old.

ENGINEERING SOCIETIES.

COMING MEETINGS.

AMERICAN ELECTROCHEMICAL SOCIETY.
April 25 to 27. Annual meeting at Boston and Cambridge, Mass. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

NATIONAL MUNICIPAL LEAGUE.
April 25 to 28. Annual convention at New York, N. Y. Secy., C. R. Woodruff, Philadelphia, Pa.

INTERNATIONAL RAILWAY CONGRESS.
May 3 to 15, 1905, at Washington, D. C. Secy. of American Committee, W. F. Allen, 24 Park Place, New York.

AMERICAN WATER-WORKS ASSOCIATION.
May 8 to 12, 1905. Annual meeting at West Baden, Ind. Secy., J. M. Diven, Charleston, S. C.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
May 16, 1905. Annual meeting at New York, N. Y.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
June 6, 7, 8, 9, 1905. Annual spring convention, at Scranton, Pa. Secy., F. R. Hutton, 12 West 31st St., New York, N. Y.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
June 6 to 9, 1905. Annual convention in New York. Secy., Richard Moldenke, Watchung, N. J.

MASTER CAR BUILDERS' ASSOCIATION.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 14-21, 1905. Annual meeting at Manhattan Beach, N. Y. Secy., J. W. Taylor, The Rookery, Chicago, Ill.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 19 to 23, 1905. Annual convention at Asheville, N. C. Secy., R. W. Pope, 95 Liberty St., New York, N. Y.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
June 20 to 23. Annual convention at Cleveland, Ohio. Secy., Charles Warren Hunt, 220 West 57th St., New York, N. Y.

LEAGUE OF AMERICAN MUNICIPALITIES.
August 23 to 25. Annual meeting at Toledo, O. Secy., J. McVicar, Des Moines, Ia.

CANADIAN SOCIETY OF CIVIL ENGINEERS.—A meeting of the General Section will be held at the society house, 877 Dorchester St., Montreal, P. Q., at 8 p. m., Thursday, April 20. Two papers will be read: "The Construction of a Timber Dry-Dock at Baltimore, Md.," by G. B. Ashcroft, and "The Bout de l'Isle Bridge," by J. L. Morris. Secy., C. H. McLeod.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The last monthly meeting of the current season will be held at the society house, 12 West 31st St., New York City, on the evening of Tuesday, April 25. Mr. G. C. Henning will read a paper on "Diamonds and Diamond Tools," which will be illustrated with lantern views and demonstrations. Ladies are invited to be present at the meeting.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The April meeting will be held in the Chapter Room of Carnegie Hall, 154 West 57th St., New York, on the evening of April 28, 1905. Four papers will be presented for discussion, as follows:

"Polyphase Metering," by J. D. Nies, Chicago, Ill.; "Notes on the Use of Instruments on Switchboards," by F. P. Cox, Lynn, Mass.; "The Oscillograph and Its Uses," by L. T. Robinson, Schenectady, N. Y.; "Maintenance of Meters," by W. J. Mowbray, Brooklyn, N. Y.

ENGINEERS' SOCIETY OF WESTERN PENNSYLVANIA.—A meeting of the Chemical Section will be held at 410 Penn Ave., Pittsburg, Pa., on the evening of Thursday, April 20. Mr. A. Gross will read a paper entitled "The Value of Pure-Food Legislation." On April 25 the Structural Section holds a meeting, with a paper on "Concrete-Lined Mine Shafts," by Mr. F. R. Dravo. On May 2 the monthly meeting of the Mechanical Section will be held, with a paper on "The De Knight Rapid-Fire Gun," by Mr. C. M. Clark. Arrangements are being made for a smoker of the society, to be held near the end of April.

MEMPHIS ENGINEERING SOCIETY.—The April meeting of the society was held at its rooms, 127 Madison St., Memphis, Tenn., on the evening of April 11. Mr. W. D. Edwards read a paper describing a new compound steam engine of his design, for which he claims the economy of the compound with the simplicity and cheapness of the simple engine. The principle employed is applicable also to pumps and to air compressors. At the next meeting, to be held on May 9, Mr. J. B. Cook will read a paper on "The Effects of Electric Currents on Adjacent and Surrounding Materials," which will refer particularly to steel-frame buildings. Secy., C. C. Pashby.

TECHNICAL PUBLICITY ASSOCIATION.—The advertising representatives of a large number of concerns engaged in the manufacture of machinery and allied industries have formed an organization to be known as the Technical Publicity Association. The first annual meeting, dinner and election of officers will be held in the rooms of the Hardware Club in the Postal Telegraph Building, New York City, on the evening of April 27, when an address will be delivered by Mr. Emerson T. Harris, well known as a broker of trade and technical journals. Mr. G. H. Gibson, International Steam Pump Co., Harrison, N. J., is Temporary Secretary of the association.

MASTER CAR BUILDERS' ASSOCIATION.—The committee on the design of arch bars for 100,000-lb. cars has issued a circular of inquiry as to the practice of railways and car building companies in regard to the details of arch-bar or diamond frame trucks for freight cars of large capacity. Information is to be sent to the chairman of the committee, Mr. T. E. Muhlfeld, General Superintendent of Motive Power of the Baltimore & Ohio R. R., Baltimore, Md.

The office of Mr. Jos. W. Taylor, Secretary of this Association, and of the American Railway Master Mechanics' Association and the Western Railway Club, has been removed to 390 Old Colony Building, Chicago.

SOCIETY OF ENGINEERS OF EASTERN NEW YORK.—The annual meeting of the Society of Engineers of Eastern New York was held at the Kenmore Hotel, Albany, N. Y., Thursday, April 12. The following officers were chosen for the coming year: President, Prof. O. H. Landreth, Mechanical Engineering Dept., Union College, Schenectady; Vice-President, Capt. Odus C. Horney, Ordnance Dept., U. S. A., now stationed at the Watervliet Arsenal; Treasurer, Mr. W. I. Slichter, General Electric Co., Schenectady; Member of Finance Committee, Mr. J. A. Kinkead, American Locomotive Co., Schenectady; Member of Executive Committee, Mr. F. B. Crane, City Engineer, Amsterdam. Nineteen new members were elected, bringing the total membership of the society at the close of its first year up to 187. At the close of the business session the members enjoyed a very pleasant smoker and were entertained by the Empire Quartette of Troy. Secy., Albert E. Cluett, Troy, N. Y.

IRON AND STEEL INSTITUTE.—The program of papers for the annual meeting (May 11 and 12, at the Institution of Civil Engineers, London) includes the following: "Experiments on the Fusibility of Blast-Furnace Slags," by O. Boudouard, of Paris, France; "Recent Developments of the Bertrand-Thiel Process," by J. H. Darby, of Brymbo, and G. Hatton, of Brierley Hill; "The Application of Dry-Air Blast to the Manufacture of Iron," by James Gayley, of New York, N. Y.; "The Effect Produced by Liquid-Air Temperature on the Mechanical and other Properties of Iron," by R. A. Hadfield; "The Cleaning of Blast-Furnace Gas," by A. Sahlin, of London; "The Failure of an Iron Plate Through Fatigue," by S. A. Houghton, of London; "The Continuous Steel-Making Process in Fixed Open-Hearth Furnaces," by S. Surzycki, of Czenstochowa, Poland; "Accidents Due to the Asphyxiation of Blast-Furnace Workmen," by B. H. Thwaite, of London; "The Behavior of Sulphur in Coke in the Blast-Furnace," by Prof. F. Wüst and P. Wolff, of Aachen, Germany. Reports on research (scholarship) work carried out during the past year will be submitted by Messrs. C. O. Bannister, J. D. Brunton, H. C. H. Carpenter, J. C. Gardner, G. Dillner and A. F. Enström, E. G. L. Roberts and E. A. Wraight, F. Rogers, and W. Rosenhain, the past year's holders of Andrew Carnegie Research scholarships.